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MEMOIRS OF THE GEOLOGICAL SURVEY.

SCOTLAND.

THE GEOLOGY OF ISLAY,

INCLUDING

ORONSAY AND PORTIONS OF COLONSAY AND JURA.

(EXPLANATION OF SHEETS 19 AND 27, WITH THE WESTERN PART OF SHEET 20.)

BY

S. B. WILKINSON.

WITH

NOTES

BY

J. J. H. TEALL, D.Sc., F.R.S., AND B. N. PEACH, LL.D., F.R.S.

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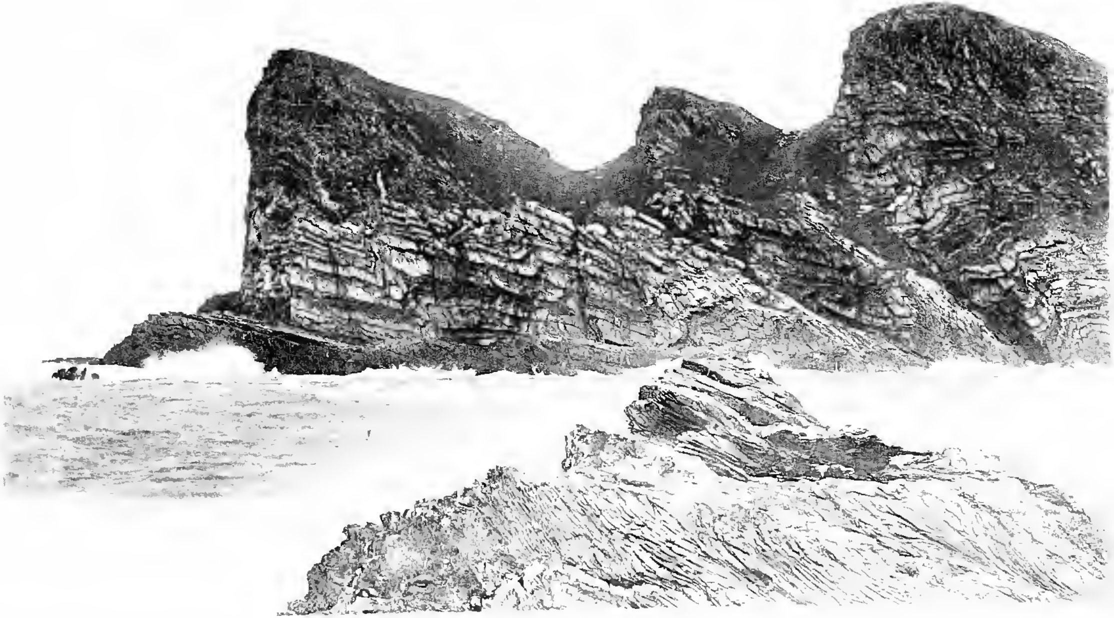

Kilchiaran Slates and Grits (Torridonian ?).
Eilean Mòr; seen from Tòn Lagain. North [illegible]est of [illegible]. *Frontispiece.*

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PREFACE.

THIS Memoir describes the geology of the island of Islay, the strip of Jura bordering the Sound of Islay, and Oronsay lying to the south of Colonsay, which are included in Sheets 19, 27, and part of 20 of the one-inch map of Scotland. These areas were surveyed by Mr. S. B. Wilkinson under the supervision of Dr. B. N. Peach. When the survey of Islay was in progress, Mr. Clough visited the island and assisted with the detailed mapping of the tract adjoining Portaskaig on the east coast.

The geology of Islay presents features of special interest. The acid and basic gneisses of the Rhinns have been correlated with the Lewisian gneiss of the North-West Highlands, and are there covered unconformably by a succession of sediments resembling some of the subdivisions of the Torridon Sandstone in the counties of Sutherland and Ross. The character of the metamorphism presented by the gneisses of the Rhinns is similar to that seen in the masses of Lewisian gneiss which have been driven westwards by the post-Cambrian thrusts in the north-west of Scotland. The rock-groups in the south-eastern part of Islay have been linked with corresponding types in the Eastern Highland sequence.

This Memoir has been written by Mr. Wilkinson, with the collaboration of Dr. B. N. Peach. I am responsible for the microscopical petrography and for certain paragraphs relating to the Lewisian gneiss.

The list of publications referring to the geology and mineralogy of the island has been prepared by Mr. Tait.

The photographs reproduced in Plates I. to VIII. were taken by Mr. Robert Lunn of the Geological Survey.

The Memoir has been edited by Mr. L. W. Hinxman under the supervision of Dr. Horne.

J. J. H. TEALL,
Director.

Geological Survey Office,
28 Jermyn Street, London,
3rd May, 1907.

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THE GEOLOGY OF ISLAY.

CHAPTER I.

The island of Islay, one of the principal islands of the Inner Hebrides, has an area of two hundred and thirty-five square miles, and forms part of the county of Argyll. Its greatest length, measured from north to south, is 25½ miles, its greatest breadth about twenty miles.

The island is divided into two distinct areas, which at an earlier period, indicated by the 50-feet raised beach, evidently formed two separate islands, but are now connected by the strip of marine and freshwater alluvium that lies between Loch Indaal and the head of the tidal estuary of Loch Gruinart.

The western area, known as the Rhinns of Islay, extends in the form of a peninsula from Ardnave Point in the north to Rhinns Point in the south, a distance of rather more than seventeen miles; with a maximum breadth, measured between Coul Point on the western coast and Tynacoille on the shores of Loch Indaal, of about six miles. The land rises gradually inland, the highest point being Beinn Tart a' Mill, 735 feet above sea-level. From the coast inland the lower slopes are under cultivation and yield good crops, while from the margins of the cultivated land extensive tracts of undulating moorland extend to the higher ground. The whole of the western coast line from Ardnave Point to Portnahaven is, with the exception of one or two small areas, bold and rugged, particularly the cliffs in the neighbourhood of Sanaig, and from Kilchiaran Bay to the southern point of the Rhinns of Islay. The northern portion of the peninsula is more undulating and mostly occupied by large tracts of peat moss and marsh, while huge sand-dunes rise on both sides of the entrance to Loch Gruinart.

The second and larger portion of the island lies to the east of Loch Gruinart and Loch Indaal, extending from Rhuvaal Point in a south-south-easterly direction to the Mull of Oa, and is bounded on the east by the Sound of Islay and on the south by the Atlantic Ocean. The highest ground is found along an irregular line drawn from a point about midway along the Sound of Islay to Port Ellen, forming the principal watershed of the island. This ridge is continued at a lower elevation from Port Ellen to Beinn Mhor, the southernmost point of the island.

In the region to the north of the valley of the Sorn the ground rises gradually towards the centre of the area in a succession of ridges and valleys, the greatest elevation reached being 1192 feet above sea-level. The country to the east of Loch Gruinart is generally barren and uninteresting in appearance, and contrasts with the coast scenery of the eastern and south-eastern seaboard, which is bold and varied in the extreme, particularly in the south-east, where numerous skerries and islets form picturesque groups. The cliffs of the Oa promontory are very fine, and rise from the sea to a height of 656 feet.

The chief watershed in this area coincides for the greater part of its course with the quartzite ridge that extends north-east and north from Port Ellen to Portaskaig. It follows a sinuous course along the tops of the principal hills of the island, including Beinn Sholum (1136 feet), Beinn Uraraidh (1490 feet), Beinn Bheigeir (1609 feet, the highest point in Islay), Glas Bheinn (1544 feet), and Sgorr nam Faoileann (1407 feet).

The streams on the south-eastern slopes of this water parting run directly to the sea, as do those on the west as far as Sgorr Bhogachain, to the north of which hill the river Laggan receives the western drainage. A second watershed, more or less parallel with the above-mentioned, extends in a south-westerly direction from Rhuvaal Point in the north-east, over Beinn Thrasda (852 feet), Sgarbh Breac (1192 feet), Guir Bheinn (1036 feet), Tais Bheinn (671 feet), and Beinn Cham, to the head of Loch Indaal. The water drains off the south-eastern slopes of these hills into the river Sorn, while on the north-west many of the streams run directly to the sea and others into the river which falls into the head of Loch Indaal. A minor watershed, running south-west from Beinn Bharradail to the east of Bridgend, separates the valley of the Laggan from that of the Sorn. The largest river basin in the island is that of the Laggan, whose head-waters drain the western side of the quartzite ridge—the principal watershed of the island—and the south-eastern slopes of Beinn Bharradail. At Kilennan a large burn of the same name joins the Laggan, and the river from this point follows a winding course westwards towards the sea between high banks of boulder clay, often passing through wide areas of alluvial land. At Bridge House, where the lower road between Bowmore and Port Ellen crosses the river, the latter runs for a short distance between walls of rock, but immediately below the bridge enters a wide plain occupied by marine and freshwater alluvial deposits and blown sand. Just before entering the sea, the Laggan is joined by the Duich river, which flows out of Lochs Beinn Uraraidh and Leathan an Sgorra, near the summit of the quartzite range. The Laggan is a very swift river, and rises and falls with great rapidity, owing in a great measure to the number of sheep-drains which carry off the surface water very quickly.

The Sorn comes next in size and in extent of its drainage basin. It is fed by the waters of Loch Finlaggan and a succession of smaller lochs in the neighbourhood of Ballygrant, the various streams which flow out of these lochs combining at Emeraconart to form the river Sorn. About half a mile below this point its volume is increased by the waters of the burn that drains the hill slopes around Ballachlavin and Duisker. The river continues its course through a tract of flattish drift-covered country to a point just below the cloth mill, one mile east by north of Islay House. Here the stream has cut through the boulder clay to the underlying rock and flows through a deep gorge, which at the Stone Cottage expands into a wide tract of alluvial land where the river is joined by a burn from the north-west slopes of Beinn Bharradail. The old course of the river wound through these alluvial flats, but the stream now pursues a straight course westward from Stone Cottage to Bridgend and falls into the sea at the head of Loch Indaal.

The area north of Cnoc Donn is watered by a stream which formerly entered the sea at Craigens on Loch Gruinart. Its course was, however, altered many years ago in order to facilitate the reclamation of the Gruinart Flats, and it now falls into Loch Indaal. The principal stream on the eastern side of the quartzite range is the Abhuinn Staoin or Kintour river, which flows from Beinn Uraraidh and Sgorr Bhagachain, and passes through a beautifully wooded district to the farmstead of Kintour, whence it winds through a tract of alluvium to the sea at Aros Bay.

All along the eastern slopes of the range above mentioned there are numerous smaller burns running directly to the sea. Many of these are intercepted and used in working the distilleries, built at intervals along this coast.

Extensive tracts of low ground are found in different parts of the island. From Kilennan and Loch Tallant in the Laggan valley there stretches south to Port Ellen a vast extent of gently-sloping ground covered with drift and large areas of peat moss. The glacial deposits consist of boulder clay, which contains a large percentage of quartzose material, and affords a very cold and infertile soil. As these slopes along their seaward margin approach the raised beaches and alluvial flats the appearance of the country changes, the latter formations yielding rich crops whose brilliant green colour contrasts in a very marked degree with the barren heather-covered or rushy boulder clay slopes. Another large area, very similar to the last, lies to the east of Loch Gruinart, where the drift-covered slopes fall gently from the base of the quartzite hills to the raised beaches and dunes of blown sand along the coast-line.

Loch Gorm, the largest sheet of water in the island, occupies a shallow depression in the superficial deposits between Kilchoman and Ballinaby in the northern part of the Rhinns. It is about one mile and a half long by one mile and a quarter broad, and contains two islands, upon one of which are the ruins of an old castle. Further to the north are Loch Corr, connected with Loch Gorm by the little river Leòig; Loch Laingeadail, surrounded by peat bog; and Ardnave Loch, situated between raised beaches and hills of blown sand. In the area to the east of Loch Gruinart the lochs are very numerous and occur at various elevations. Loch Smigeadail in the north-east lies at an altitude of 700 feet above sea-level. Lochs Ardnahoe, Staoinsha, and Torrabolls form a group of small lakes a short distance north of Portaskaig. The two last-named lochs supply water to the distilleries of Bonahaven and Caol Isla respectively.

Finlaggan Loch, 169 feet above sea level, with its very interesting ruined castle, lies in the narrow valley between Cnoc an Tigha and Robolls Hill. Three lochs are grouped together to the east of the village of Ballygrant, viz., Loch Cadhan, Loch Chuirn, and Loch Lossit. The two latter are beautifully situated, and contain water of exceptional clearness and brilliancy issuing from springs in the adjacent limestone. Loch Cam occupies a hollow between two quartzite hills about three miles north of Bridgend, and nearer that village is Loch Skerrols, a fine sheet of water partially artificial, a dam having been built to retain a head of water sufficient to drive the mills at Islay House. Loch Tallant, three miles south of Bridgend, appears on the map as a loch, but is little more than a marsh, and is rapidly becoming filled up with water plants. A small lochan about a quarter of a mile west of Loch nam Breac is known locally as the loch of the "tailless trout," trout having been taken out of it deficient in some of their fins. A number of small lakes of different sizes—Lochs na Breac, Beinn Uraraidh, Sholum, Uigeadail, Leathan an Sgorra, and Leorin—with many other smaller pools, occur along both sides of the quartzite ridge north-east of Port Ellen. Many of the small lochs on the east side of Laggan Bay have been considerably reduced by drainage, and are to a large extent choked with vegetation. On the promontory of the Oa are Upper and Lower Glenastle Lochs, and near the Mull of Oa Lochs Ardachie and Kinnabus.

The climate is exceptionally mild; the annual mean temperature is 47.5°, that of the three winter months being as high as 40.1°. The tenderest plants will thrive if sheltered from the winds, and fuchsias grow with great luxuriance. Snow does not lie even on the hills for any length of time, but the rainfall is large, the average annual precipitation measured at Bridgend being 49.13 inches. The months of April, May, and June are generally dry; after that period fine weather cannot be depended on. There is, however, generally a fortnight or three weeks in October and November before the fall of the leaf when the climate is all that can be desired, and the colouring of land, sky, and sea superb. The scenery of Islay is very varied, some districts being very bleak and barren, while others have the character of a lowland rather than a highland country. The raised beaches around Bridgend, at the head of Loch Indaal, form very effective natural features, which have been taken advantage of for planting in the grounds of Islay House. The timber has grown well, and considering the severe nature of the storms that visit the island, many of the trees are above the average, some of the beeches and silver fir in Daill Wood being very fine. On both sides of the road from Bridgend to Port-askaig the scenery again is more like that of the lowlands, with verdant pastures, well-cropped fields, and patches of natural timber. This fertility is due to the underlying limestone, for in the same area, directly the quartzite is reached the growth of timber ceases. A similar change is seen in the southern area, and over the wide tracts of boulder clay which contains a large quantity of siliceous material. Between Port Ellen and Ardtalla, in the south-east of the island, the scenery is very striking. The white gleaming summits and slopes of the quartzite range rise conspicuously in the background, flanked by dark igneous rocks that weather out into picturesque jagged ridges clothed with the indigenous tree growth of the country. These nearer features combine with the brilliant colouring of the sea, the blue line of the distant hills of Knapdale, and the peaks of Arran beyond Cantyre, to invest this portion of the West Highlands with remarkable beauty.

S. B. W.

CHAPTER II.

Progress of Geological Research in Islay.

The geology of Islay has, during the past hundred years, attracted the attention of several eminent observers. As far back as the year 1789, Mr. Abraham Mills, in two letters communicated to the Royal Society,* recognised the intrusive character and basaltic nature of the dolerite dykes of Islay. He also refers to the high-level beaches, and considers them to indicate a recession of the sea. A similar conclusion was reached by Robert Jamieson, writing in 1800.†

The results of the examination of the Western Islands by that far-seeing observer Macculloch, were published in 1819,‡ and, with regard to the geology of Islay, anticipate in several points the conclusions of later geologists. Macculloch points out that on the east shore of the Rhinns, clay slates (Kilchiaran slates and grits) alternate with a felspathic hornblendic gneiss which he compares to that of Iona and the Outer Hebrides. He also refers to the conglomerate of Portaskaig and Lossit Hill as a *primary* conglomerate, correlating it with a similar rock on the Garvelloch Isles and on Schehallion (boulder-bed of Perthshire); and also pointing out that in addition to pebbles of granite foreign to the island, it contains fragments of the limestone upon which it lies. He was also probably the first to discover the igneous nature of the rocks of Glas Eilean, in the Sound of Islay. He describes the rock as an amygdaloidal trap, and suggests that it may once have covered a large area and have been the source of the trap veins (Tertiary dolerite dykes) of Jura and Islay.

Professor J. Nicol, in his description of the metamorphic rocks of Islay,§ 1844, confirms the observations of Macculloch as to the alternation of clay slate with gneiss on the eastern shore of the Rhinns, and the contents and position of the conglomerate of Portaskaig and Lossit Hill.

In their paper on the Western Islands of Scotland, communicated to the Geological Society in 1861,|| Sir R. Murchison and [Sir] A. Geikie make the following references to the geology of Islay:—

The grits and schists (Torridonian) of the north-west part of the island are regarded as the equivalents of the lower quartz-rock (Cambrian) of Sutherland, at that time supposed to be of Lower

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* Philo. Trans. Roy. Soc., Vol. LXXX., p. 73. 1790.

† Mineralogy of the Scottish Isles, Vol. II., pp. 146-166. 1800.

‡ Western Islands of Scotland, Vol. II., p. 223; Vol. III., pl. 22. 1819.

§ Guide to the Geology of Scotland, 1844, p. 225.

|| Quart. Jour. Geol. Soc., Vol. XVII., p. 206.

Silurian age. They describe the whole of the area of the Rhinns as occupied by these grits and schists, into which the granitoid igneous rocks of the southern part of the promontory (Lewisian gneiss) have been intruded. The (Islay) limestones of the central valley are referred by these observers to the horizon of the Assynt limestone, and the overlying quartzite to that of the "upper quartz-rock" (over-thrust Cambrian quartzite) of West Sutherland. They further point out that the Islay limetones extend north-east through the Garvelloch Isles to Lismore and Shuna, and that the overlying quartzite and "upper schistose series," after traversing Jura and Scarba, reappear on the north of Oban.

Attention is also drawn to the great development of hornblendic igneous rock in the form of intrusive sheets—their parallel arrangement, and the contact alteration which they have produced on the surrounding rocks.

The results of the recent work of the Survey in Islay have been also in some degree anticipated by the late Mr. James Thomson, F.G.S. His views are embodied in a paper read before the British Association at Edinburgh in 1871,* and are further expanded in a communication to the Glasgow Geological Society in 1875.†

Mr. Thomson was the first to pronounce definitely as to the Laurentian (Lewisian) age of the gneiss of the Rhinns of Islay. He lays stress on the difference in age between these rocks and those of the central parts of the island, and points out their close lithological resemblance to the fundamental gneiss of Sutherland and the Outer Hebrides. The rest of the metamorphic rocks of Islay he assigns to three different periods. The strata along the west side of the Sound of Islay, between Bonahaven Bay and Lossit (dolomitic shales and flags, quartzites, and Portaskaig conglomerate of the survey), he groups with the slates and grits of the area between Skerrols and Sanaig, regarding the whole as of Lower Cambrian (Torridonian) age, and further suggests the resemblance of the shales and flags of the Sound of Islay—with suncracks, rain drops, and annelid markings—to similar rocks of Cambrian (Torridonian) age in Sutherlandshire, and on the Longmynd in Wales. To the Upper Cambrian (Torridonian) is assigned the quartzite of the south-eastern belt, together with the underlying slates and limestones of the central region, while the quartzite of the Mull of Oa is separated from that mentioned above and included with the schistose series to the east (Port Ellen phyllites) as being on the horizon of the lower members of the Lower Silurian. Mr. Thomson also notes the occurrence of a breccia-conglomerate on either side of the eastern belt of quartzite, but regards that on the east as the base of an overlying schist series. He further recognises the granite fragments of the Portaskaig conglomerate as foreign to the island, and attributes their presence to the agency of ice.

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* "On the Stratified Rocks of Islay." Brit. Ass. Rep., 1871, Vol. XLI., p. 110.

† "On the Geology of the Island of Islay." Trans. Geol. Soc. of Glasgow, Vol. V., p. 200.

The official survey of Islay was begun in the year 1890 and continued during the next eight years. In the Annual Summary of Progress for 1893* attention was first drawn to the close resemblance of the dolomitic shales and quartzite of the north-eastern part of the island to the "fucoid-beds" and quartzite of West Sutherland and Ross. The occurrence was noted of a conglomerate at the base of the quartzite, similar to the "boulder-bed" of Central Perthshire, and it was suggested that the Islay and Jura quartzite might be a continuation of that of the Central Highlands. In 1896† a possible Lewisian age was attributed to the gneisses of the south-west promontory; but it was not until the next year that the identification of the rocks of the Rhinns with the Lewisian gneiss and Torridonian of the North-West Highlands was confirmed in the official publications of the Survey.‡

In the former year Messrs. Peach and Wilkinson had come to the conclusion that the south-eastern or Beinn Bhan quartzite rested unconformably upon the limestone and schists. Further observation in 1897 confirmed their views as to the relations of the schists and quartzite on either side of the Beinn Bhan quartzite belt, and to the overlap of the latter across the limestones on to the phyllite zone.

Finally, in 1899,§ a critical examination by the same two officers of the coast sections on the west side of the Sound of Islay established the order of succession of the strata which has been adopted in the present memoir.

L. W. H.

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* Summary of Progress of the Geological Survey for 1893, p. 265.
† *Ibid* for 1896, p. 26.
‡ ,, for 1897, pp. 62-64.
§ ,, for 1899, p. 66.

CHAPTER III.

FORMATIONS AND ROCK GROUPS. GENERAL GEOLOGICAL STRUCTURE OF THE AREA.

The following formations and groups of rock enter into the composition of the area under consideration:—

Sedimentary.

		Sign on Map.
Recent and Post-Tertiary.	Blown sand.	
	Peat	—•—
	Freshwater alluvium	⌒⌒
	Marine alluvium and raised beaches	‿‿
Glacial.	1. Striae	—⊖—
	2. Boulder clay.	
	3. Moraines.	
	4. Sands and gravels.	
Triassic?	Breccia and red sandstone of the Mull of Oa.	
(Lower ?) Old Red Sandstone.	Basic lavas and red sandstones of Glas Eilean	Poc^1

Metamorphic.

		Sign on Map.
Northern Series.	5. Dolomitic shales and massive cream-coloured dolomites	$\mathfrak{x}^2$
	4. False-bedded quartzite with annelid "pipes"	$\mathfrak{x}^1$
	3. Shales, flags, and dolomite	$\mathfrak{x}^2$
	2. Quartzite with band of conglomerate	$\mathfrak{x}$
	1. Portaskaig conglomerate	$\mathfrak{x}$ & $\mathfrak{z}$

(This series is everywhere separated from the Torridonian rocks by the Loch Skerrols thrust-plane.)

				Sign on Map.
Southern Series, correlated with Central Highland Rocks.	Group II.	Quartzite and conglomerate (Beinn Bhan quartzite)		$\mathfrak{x}$ & $\mathfrak{z}$
	Group I.	*d.* Islay limestone = Lismore and Loch Awe limestone of the mainland		λ
		c. Black slates and phyllites (Esknish slates) = Easdale slates		$\mathfrak{g}^i$
		b. Port Ellen phyllites	Ardrishaig =phyllites.	$\mathfrak{l}$
		a. Laphroaig quartz-schist		$\mathfrak{x}$

Torridonian.	*c.* Bowmore grits = Applecross and (in part) Aultbae groups of the mainland .		t ?
	b. Kilchiaran slate and grit series	Diabaig Group.	
	a. Epidotic grit and basal conglomerate		
Lewisian.	Gneiss of the Rhinns of Islay.		𝔄

Igneous.

Foliated in whole or in part.	Epidiorites	B^G
	Lamprophyres and mica traps . .	S^M
	Felsites	F
Unfoliated.	Basalts and dolerites	B

GENERAL GEOLOGICAL STRUCTURE OF THE AREA.

For convenience of geological description the island of Islay may be divided into two portions, viz., the Rhinns or western area and the eastern area. The western area comprises the whole of that portion of the island known as the Rhinns of Islay together with a belt of country lying round the head of Loch Indaal. It is separated geologically from the eastern area by the Skerrols thrust-plane, which follows a sinuous southwards course from Bun-an-uillt on the east shore of Loch Gruinart and crosses Loch Skerrols, where the evidence of great movement is plainly seen. It thence passes to the east of Bridgend by Tallant Farm, where it is shifted eastwards by a normal fault. Beyond that point its course is concealed under superficial deposits, but probably continues to the shores of Laggan Bay.

With the exception of numerous intrusive dykes, the western area is entirely occupied by rocks of pre-Cambrian age. Torridonian grits, slates, and conglomerate form the northern and larger portion of the region, while the acid and basic gneisses of the Lewisian complex occupy that part of the Rhinns which lies south of Kilchiaran Bay and Bruichcladdich. Rocks of Torridonian age, largely covered by blown sand and marine deposits, also form the island of Oronsay and that portion of Colonsay which falls within the map.

The eastern division of Islay is occupied by two series of metamorphic rocks—Northern and Southern Series—whose respective ages and mutual relations have not yet been determined with absolute certainty.

The rocks included in the Northern Series cover the greater part of the north-eastern region between the Loch Skerrol thrust-plane and the Sound of Islay, and consist of shales, dolomites, quartzites, and conglomerates, the last-named occurring both at the base and at higher horizons of the quartzite. The shales and dolomites, repeated by folding and step faults, form several irregular masses in the centre of this area, and fringe the shore of the Sound at Bonahaven Bay and Na Feamindean. The siliceous and conglomeratic rocks that underlie the shales and dolomite occupy considerable areas on either side of the irregular masses described above, and form a narrow strip along the shore of the Sound of Islay as far south as Rudha Bhoraraic, where the basal or Portaskaig conglomerate is separated by a line of discordance from the quartzite of the southern area, about to be described.

The second or Southern Series is made up of quartz-schists, slates, phyllites, and limestones (Islay limestone), together with an overlying zone of quartzite—the Beinn Bhan quartzite—and conglomerate. The two last of these subdivisions are considered to be on the same horizon as the corresponding rocks of the Northern Series, with which they closely agree in lithological character. The whole series has further been correlated with a similar sequence of rocks in the Central Highlands or Perthshire Series.

The rocks of the Northern Series in the north-east part of the island are clearly younger than the phyllites and Islay limestone of the Southern Series upon which they rest unconformably, and fragments of which are included in the conglomerates at their base.

Similar relations obtain between the quartzite and conglomerate on the one hand and the schists and Islay limestone on the other, along the western margin of the southern belt of siliceous rocks, south of the head of the Kilennan river; a fact which strengthens the supposition, referred to above, that these quartzites are on the same horizon as those of the Northern Series.

The rocks of the Southern Series occupy the whole of the southern and south-eastern parts of the island. The Beinn Bhan quartzite forms a belt gradually widening to the north that extends across the island from the Mull of Oa to the Sound of Islay. On either side of this belt the phyllite and limestone zone is disposed in bands of unequal breadth, the one extending from the Mull of Oa to within a short distance of Portaskaig, the other fringing the south-eastern shore between Port Ellen and Maol Ardtalla.

A narrow strip of quartzite, let down by a fault with a downthrow to west, also forms the north-west side of the Oa promontory.

Sills of epidiorite and hornblende schist occur in great numbers within the slate and phyllite belt on the south-eastern coast between Port Ellen and Carraig Mhor, and there is also a group of similar intrusions around Beinn Bhan in the centre of the island. Dolerite dykes of Tertiary age with a general north-western and south-eastern trend are abundant in most parts of the island, and visible in greatest abundance along the north-western and south-eastern shores of the Rhinns. L. W. H.

FOLDING AND METAMORPHISM OF THE STRATA.

Islay, like the Central Highlands to which it properly belongs, bears evidence of having been subjected to great tangential pressure, whereby its rocks have been thrown into a succession of subparallel overfolds, the longer axes of which trend generally in a north-eastern and south-western direction. The island is a continuation of a tract of country which lies to the north-west of the great central belt in which the strata are vertically folded, forming a pseudo-fan structure, the axis of which traverses the West of Scotland from about the south-west end of Loch Awe to the head of Loch Sween. In conformity with the structure of that area, the axial planes of the Islay folds are for the most part inclined towards the south-east and south-south-east, though there is a small belt in the centre of the island where a minor fan-like structure has been partially developed, on the south-east side of which the planes dip in an opposite direction.

In addition to this overfolding, there is evidence of over-thrusting along the Loch Skerrols thrust-plane. Up this inclined plane the rocks of the central part of Islay have been thrust bodily westwards over the Torridonian strata of the Rhinns. It is therefore obvious that the direction of movement was from south-east to north-west.

In the western area all the rocks, with the exception of some newer dykes, are involved in a series of minor overfolds whose axial planes all dip south-eastwards. The type of folding is well illustrated in the frontispiece, a view of the well-known Sanaig rocks seen from the south-east. Plate I. is a photograph of folded strata showing intense puckering near the western shore of Loch Gruinart. These puckered rocks of the Rhinns are further arranged in a compound anticline the axis of which coincides roughly with the central line of the promontory. This is well illustrated on sheet 19 by the disposition of the Torridonian sedimentary rocks upon the Lewisian gneiss and also in the horizontal section (fig. 1). Unfortunately in the ground at the head of Loch Indaal, between the Rhinns and the rest of the island, the rocks are concealed under superficial deposits. At Blackrock, where the Torridonian arkoses are first seen, the evidences of folding and deformation are very slight. There is, however, a constant dip towards the east and an evident upward succession in that direction. The rocks in this district may therefore be looked upon as forming the eastern limb of the Rhinns compound anticline.

The structure of the eastern area is that of a central compound anticline or fan-like arrangement of the strata flanked on each side by a compound syncline. The anticline coincides roughly with the central plane along which the members of the underlying phyllite-limestone group come to the surface, though, owing to pitch of the folds and faulting, the overlying conglomerate-quartzite group extends across its north-eastern extension. The axial planes of the minor folds entering into this structure are variously inclined.

The northern compound syncline includes all the members of the Northern Series which form the northern range of hills. In this syncline the strata are thrown into a series of comparatively gentle overfolds, somewhat inconstant in the direction of dip of their axial planes. The structure is further somewhat obscured by a succession of large north-east and south-west step faults. The northern margin of the compound syncline is truncated by the sea, so that the phyllites and limestones do not reappear in that direction.

The southern syncline also contains a quartzite and conglomerate (Group II. of the Southern Series) and coincides roughly with the southern range of hills which stretches from the Sound of Islay to the Mull of Oa. The strata involved are all more or less sharply and isoclinally folded, with axial planes dipping south-east and south-south-east. To the south-east of the quartzite belt the phyllites reappear, but unaccompanied by the Islay limestone, pointing to an overlap of the quartzites over the latter in the intervening ground. The phyllites, together with the epidiorite sills with which they are abundantly injected, are involved in the same series of easterly inclined overfolds, the whole system forming a second smaller compound anticline which gives rise to the narrow plain which borders the coast to the east of Port Ellen. The crest, however, is marked by the outcrop of the Laphroaig quartz-schists a little to the east of Port Ellen, and its southern boundary by the basement members of the southern quartzite series from near Ardmore Point to the extreme south-east of the island.

Over the greater part of the island the evidences of mechanical destructive deformation are more apparent than those of constructive metamorphism, and where the latter has taken place it is nowhere of a high grade. In these respects also Islay is in accord with corresponding areas on the western seaboard of the mainland, though the rocks of Islay are even less altered than those of the mainland.

In the western area the effects of dynamic metamorphism are most apparent along the eastern shores of the Rhinns. In this part of the area the Lewisian rocks have been so much crushed that their original structures have been for the most part obliterated, while the overlying Torridonian sediments show an almost equal amount of deformation. The crushing is most highly developed near the junction of the two formations. Towards the south-west side of the Rhinns, however, though the rocks are much puckered and folded, the crushing is not so great, so that the igneous structures of some of the pre-Torridonian intrusions are still quite apparent (Plate II.). The Torridonian sediments, together with a series of lamprophyre dykes and sills by which they are invaded, have been folded and cleaved along a set of planes common to them and the underlying Lewisian rocks. The pelitic sediments have been converted into slates, the grits into flaser rocks, and the gneiss pebbles in basement conglomerates have been drawn out and flattened (Plate III.); but beyond the production of white mica along the movement planes there has been little or no constructive metamorphism. In the Blackrock and Bowmore parts of the area round the head of Loch Indaal the Torridon arkoses show but slight signs of deformation or alteration beyond a partial bleaching. As the outcrop of the Loch Skerrols thrust-plane is approached, signs of crushing become more and more apparent, till close up to the thrust-plane the grits are rolled out into a platy mylonite.

In the eastern area, on the eastern side of the thrust-plane, the quartzite shows similar evidence of intense deformation, which gradually decreases and dies out within a mile of the outcrop of the thrust-plane. Beyond the influence of the thrust the rocks of the central compound anticline are but little shattered and metamorphosed, and that only where the folding is most intense. In the phyllite-limestone group of the central belt the argillaceous rocks are usually cleaved into slates, and towards the south-west end of the belt on the shores of Loch Indaal the members of the lower division become lustrous phyllites, but this part of the area more properly belongs to the southern compound syncline. Towards the north-east end of the central belt the rocks show little or no signs of intimate deformation beyond the cleavage of the slates, the oolitic grains of the Islay limestones often retaining their spheroidal form. Even when there is evidence of considerable movement of the adjacent rocks, the dolomitic beds, although full of sand grains, do not seem to have set up magnesian and calc-silicates, although the same type of rock elsewhere on the mainland is proved to be particularly favourable to the production of such minerals. In the east of the central belt and in the northern compound syncline, the rocks are in many places so little affected that the sun-cracks and worm-casts which they contain have not been deformed, and many of the surfaces of the sandy dolomitic shales still glisten with derivative flakes of mica. Most of the rocks of this part of the area cannot be regarded as metamorphic in the strict sense of that term.

In the southern compound syncline, south of the central belt, there is evidence of increasing compression of the folds, accompanied by a corresponding rise in the grade of metamorphism, until towards the southern edge of the belt the rocks approach the condition of those in the Central Highlands. In the southern compound anticline also, the Port Ellen or Ardrishaig phyllites become more like those of the typical mainland areas than the equivalent rocks of the central belt of Islay.

The fact that the beds on each side of the Loch Skerrols thrust-plane, away from the immediate influence of the thrust, show less signs of folding, deformation, and metamorphism than those at a greater distance appears to be of great significance. It seems to point to the fracture having taken place at an early stage in the folding of the country so that these rocks were enabled to move in mass and thus to escape further compression.

B. N. P.

CHAPTER IV.

LEWISIAN GNEISS.

Nearly the whole of the southern portion of the peninsula of the Rhinns of Islay, to the extent of about nineteen square miles, is occupied by rocks belonging to this formation. A somewhat sinuous line, corresponding to the outcrop of the basement beds of Torridonian age, between Bruichladdich on the east coast and Kilchiaran Bay on the west, bounds this area on the north.

In the mapping of the district certain basic masses have been separated out and lettered B^G. These are, in part at least, of later date than the rocks of the fundamental complex, but the intense movement which has affected the area and modified the original relations as well as the structure of many of the rocks, often makes it impossible to speak with confidence as to the relative ages of the different varieties.

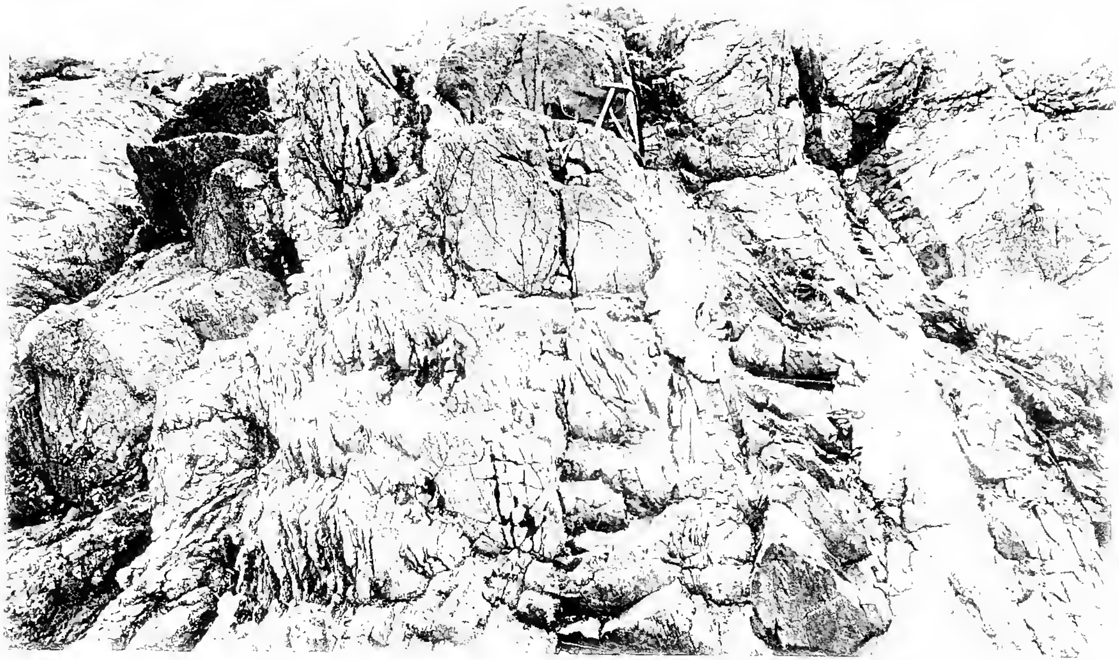
The rocks of the fundamental complex consist of acid and basic gneisses of probable igneous origin. The most striking petrographical feature of the specimens from various parts of the area which have been examined under the microscope is the evidence which they afford of changes due to pressure-fluxion. Relics of the original constituents lie in a matrix of secondary granulitic or mylonitic material, mainly composed of quartz and felspar, but containing also minute scales of biotite and chlorite, films of sericite and grains of epidote. The more basic as well as the more acid members of the series show, as a rule, the same evidence of profound modification by this dynamic action, the general result of which has been to crush the original constituents and thus to produce microscopic breccias, not holocrystalline schists. In this respect the character of the metamorphism is similar to that seen in those masses of Lewisian gneiss which have been brought forward by the great post-Cambrian thrusts in the north-west of Scotland, and differs from that which is characteristic of the zones of secondary shearing in the otherwise undisturbed areas of Lewisian gneiss occurring in the same district.

It is difficult to speak with confidence as to the original characters of the rocks of the fundamental complex, but they probably consisted of biotite- and hornblende-gneisses, not dissimilar from those occurring in areas of Lewisian gneiss. Microcline and microperthite were certainly present as constituents of the more acid varieties, while a basic felspar, now represented by saussuritic aggregates, occurred in the more basic members of the series. J. J. H. T.

A study of the area of the Rhinns, especially along the southern shore-line, shows that the rocks referable to the "fundamental complex" are cut by a series of later basic intrusions (B^G). Probably the best locality for observing the relation of the dyke-like masses to the members of the fundamental complex is on Orsay, the island south of Portnahaven upon which the lighthouse is built, where the heavy seas have washed the rocks bare of drift and raised-beach material over a wide area.

Here the fundamental complex consists chiefly of a pink porphyritic gneiss, with eyes and stripes of pink felspar set in a darker granulitic matrix and enclosing knots and elongated masses of the early basic material which are now mostly striped out into hornblende-schist. These rocks are cut by dykes and elongated masses of basic material, the larger of which are very coarse in the centre and become fine-grained towards the edge (Plate II.). They also give off numerous dykes, which when fairly large behave in the same manner as the main mass; the smaller dykes are, however, fine-grained throughout and also sheared, while the coarse parts only show a few lines of movement. The felspars are invariably represented by greenish saussuritic material, and hornblende is very conspicuous. The large intrusive mass west of the lighthouse is traversed by a band of dolomitic material, weathering a rusty ochreous colour. The walls of this intrusive mass rise at an angle of about 80° and trend in the north-eastern and south-western direction common to all the similar masses in the Rhinns area. Another good section is exposed along the ridge running from Lossit Bay to Kilchiaran. At Carn the rock is rather massive and coarse-grained. Between Am Glean and the sea the junction of this basic mass with the early complex is clearly shown: the former becomes finer-grained and darker towards its edge, and the line of junction resembles the chilled edge of an intrusion into the rocks of the early complex. The latter consists of a coarse-grained pink acid gneiss with occasional lenticular bands and irregular masses which vary in basicity from ultra-basic hornblendites to rocks containing as much felspar as hornblende or mica. None of this more acid material is seen to transgress the boundary of the dioritic rock, and it is inferred from these facts that the latter rock was intruded into the rocks of the original complex. The basic rock at Carn and Cnoc Breac shows little sign of parallel structure, but on each side of the waterfall on the Tormisdale stream a marked foliation is seen in places. This rapidly increases in intensity from this point westward to the sea, until near the junction with the acid gneiss of the original complex both rocks are found to be traversed by a set of foliation planes which strike north-east and south-west and dip north-west at high angles. North-west from Carn the foliation also increases, the direction of strike and dip being the same. Another interesting section is seen at Port Mias Sgier, north-west of Portnahaven. Here the gneiss represents the acid phase of the original complex sheared and granulitised. This is succeeded by a mass of much-decomposed igneous rock, a large part of which has been converted into epidote prior to the shearing movements to which it has been subjected. For more than 100 yards from its edge it is seen to be drawn out in a north-eastern and south-

PLATE II.



Acid and Basic Gneiss traversed by Basic Dykes, Orsay, South end of Rhinns, Islay.

western direction, the epidote veins being traversed by a series of cracks at right angles to the direction of stretching. In the cove under Claddich this rock assumes a massive character, and where not converted into epidote resembles the rock of Cnoc Breac and Kilchiaran referred to below, of which it is probably the southernmost extension. It also resembles the large basic intrusion in Orsay. S. B. W.

The basic masses are described on the tablet as consisting of epidiorite and hornblende-schist, but they include also diorites, augite-diorites, and augite-hypersthene-diorites or hyperites. Some are perfectly massive with the original structures well preserved, while others show a well-marked parallel structure. A specimen from Kilchiaran (5593) may be described as a gneissose diorite. It consists essentially of green hornblende and plagioclase with granular aggregates of apatite and iron-ores zoned with sphene as accessories. Epidote also occurs. Another specimen from the same locality (5595) consists of greenish-brown hornblende, uralitic hornblende containing kernels of unaltered augite, and plagioclase which is often crowded with small scales of white mica and grains of epidote. Iron-ores and apatite are also present. Another variety occurs at a point one and a half miles north of Cladville House (6861). It is a dark-green massive rock containing large irregular individuals of hornblende which often measure half an inch across and show lustre mottling on their cleavage faces. The constituents are brownish-green hornblende, nearly colourless augite, biotite, a basic plagioclase. and iron-ores.

A specimen from Cnoc Breac (6864) is of exceptional interest. It is a coarse-grained massive rock essentially composed of brownish-green hornblende, pale-green augite, hypersthene, biotite, and a basic plagioclase. The original structures are well preserved, and the rock may be described as an augite-hypersthene-diorite. Specimens of augite-diorite from Cultoon (6870–6872) are similar in character but contain no hypersthene. The pale-green augite occurring in the rocks from the two last-mentioned localities is precisely similar to that occurring in the pyroxene-gneisses of the north-west of Scotland, where it is also found, not infrequently, to be associated with hypersthene. J. J. H. T.

The cliff at the south end of Lossit Bay affords a very fine section of one of the basic masses with some gneiss of the original complex. The latter appears to be traversed by a mass of pegmatite. The rocks here have been beautifully polished by the blown sand. On the east coast of the Rhinns, between the road and the coast-line, a lenticular mass of highly acid red pegmatitic rock can be traced in a north-east direction between Easter Ellister and Octofad. Another interesting shore section is that extending from a little north of Bruichladdich by Port Charlotte to Carn Cottage. Here the rock has been intensely sheared, and when examined under the microscope is seen to consist very largely of mylonitic material. In the Gleann Mor stream, about five hundred yards west of Port Charlotte, the gneiss shows signs of intense movement and is drawn out into platy mylonite; the dip of the planes is generally south-east at low angles. Further down the burn the gneiss is less deformed, and in the stream behind the distillery both acid and basic material can still be recognised.

Along the line of junction between the Lewisian gneiss and the Torridonian sediments at this locality the rocks are traversed by a set of planes of schistosity that are clearly common to both formations. It has further been observed that although crushing and mylonisation of the older rocks is more or less prevalent throughout the region, the amount of shearing and deformation increases towards the margin of the sedimentary rocks, and is most intense along the actual boundary-line between the two. This is in all probability due to the unequal resistance offered by the gneiss and the overlying sediments to the shearing movement.

S. B. W.

CHAPTER V.

TORRIDONIAN.

The Torridonian rocks of Islay may be divided into three well-marked groups.

A. The Rhinns conglomerate series—a schistose grit with a few thin seams of phyllite. The grit is often highly epidotic and in places forms a local base, highly conglomeratic and containing pebbles of the underlying gneiss. This series is comparatively thin.

B. The Kilchiaran slates and grit series—consisting of grey, green, and almost black slates and phyllites alternating with grey schistose grit and thin bands of sandy limestone. Owing to the intense folding that these rocks have undergone, it is impossible to form a true estimate of their thickness, but it must be considerable.

C. The Bowmore grits—a series of red, green, and grey grits or arkoses, whose characteristic feature is the fresh condition of the felspar grains and pebbles of which they are largely composed. In places they are very coarse-grained and contain well-rounded pebbles of quartzite, felsite showing fluxion-structure, granite, and other rocks. Towards their upper limit they become fine-grained and alternate with slaty and phyllitic bands. These more massive grits are less folded than the rocks of Group B, and may be of great thickness.

A comparison of the Torridonian rocks of Islay with those of the same formation as developed in the North-west Highlands, and tabulated in the annual report of the Director-General of the Geological Survey for the year 1893, shows that Groups A and B resemble in lithological character the Diabaig group as developed in the Sleat district of Skye, and may occupy the same horizon; the Rhinns conglomerate corresponding to the basal epidotic grits of Sleat and the Kilchiaran slates and grits to the sub-divisions *b*, *c*, *d*, established by Mr. Clough in Skye. The resemblance between the Bowmore group (C) and the members of the Applecross group (2) as there described is even more striking. The more eastern and probably the upper portion of the Bowmore grit corresponds in character with a portion of the Aultbea group (3) of the northern region*

A. *Conglomerate and Schistose Epidotic Grit.*—Several sections in the Rhinns show that a zone of conglomerate and epidotic grit forms the base of the sedimentary rocks which rest unconformably

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* Annual Report of the Geological Survey and Museum of Practical Geology for the year ending December 31, 1893.

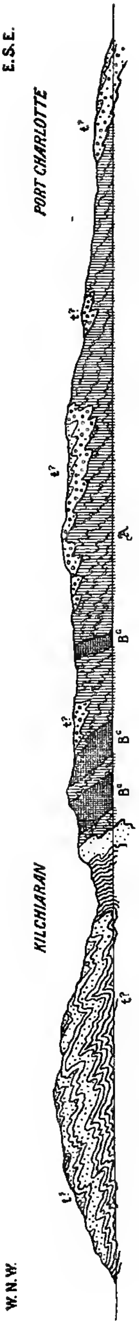


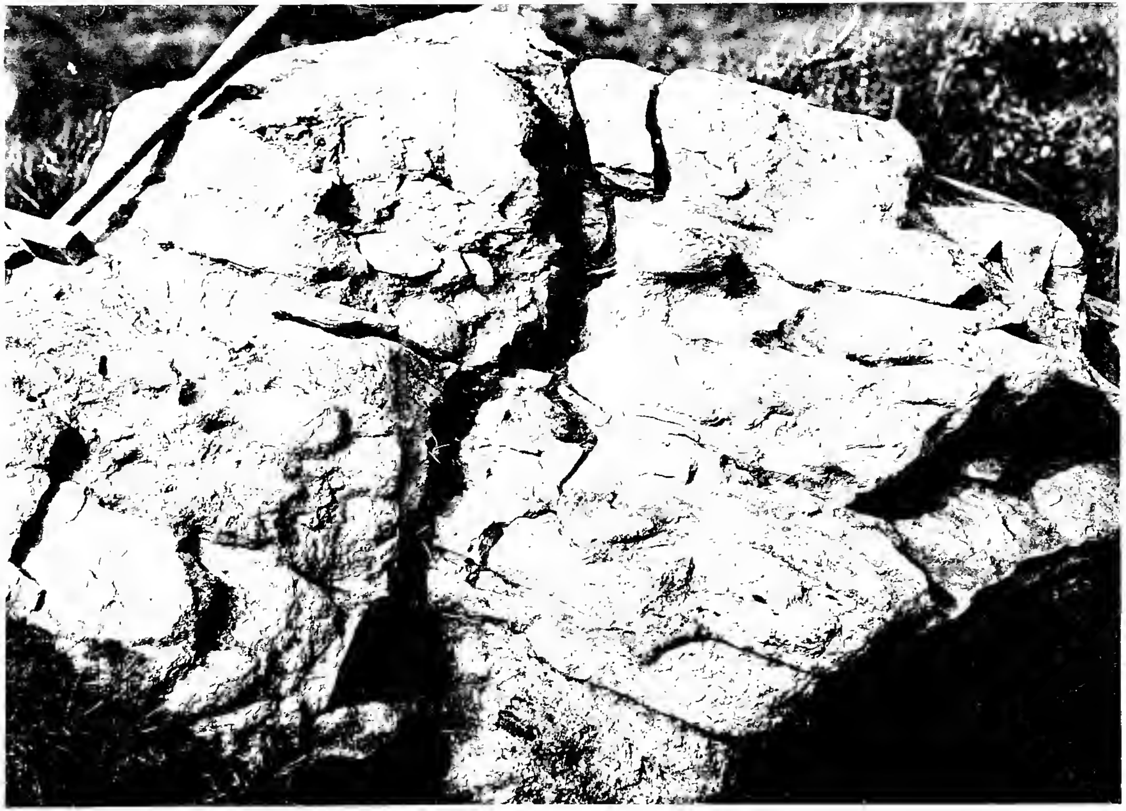
Fig. 1.—Generalised Section across the Rhinns of Islay, through Kilchiaran to Port Charlotte.

A. Gneiss, probably of Lewisian age. B^G Basic rocks of fundamental complex. t. Basal conglomerate and Kilchiaran slates and grits, probably of Torridonian age.

on the Lewisian gneiss in that area. Following the junction-line between the two formations northwards along the shore from a point on the west coast a short distance south-west of Kilchiaran Bay, the observer finds the Torridonian sediments resting in an inverted position against the gneiss, and dipping south-east at 70° to 80°. The rocks at the junction consist of dark phyllites with alternations of dark gritty bands, containing masses of gneiss similar to the adjoining coarse acid rock, one of the masses being two feet long. The conglomeratic beds are succeeded by phyllites and epidotic grits, which pass up into a succession of tough grits. The beds here resume their normal position and dip north-westwards out to sea. Two specimens of these grits from this locality have been examined microscopically. One (5605) is a coarse grit composed of sub-angular fragments up to $\frac{1}{4}$ inch in diameter embedded in a fine-grained dark-greenish matrix. The large fragments consist for the most part of quartz rock, one contains biotite in addition to quartz, another is an aggregate of microcline. Amongst the smaller fragments occur microcline, microperthite, ordinary striated plagioclase, and quartz. Sericite, biotite, and colourless micro-crystalline material enter into the composition of the matrix. The other (5606) is a grey felspathic grit containing blue quartz and large grains of felspar (mostly microcline). The matrix shows pressure-fluxion and is composed partly of smaller grains of the same two materials and partly of mylonitic material, including a little sericitic mica.

The softer phyllites and epidotic rocks weather out more readily than the gneiss on the one side and the grits on the other, producing a hollow along their outcrop. As we follow the line of junction of the gneiss and sediments south-westwards along the east side of this hollow to Eilean Liath, the junction of the dark slates or phyllites with the massive gneiss is found to be of such a nature as to preclude all possibility of any thrust or fault occurring between them. The cleavage-planes can

PLATE III.



Basement Conglomerate of Kilchiaran Slates and Grits, Dun Mideir, 2½ miles North-West of Port Charlotte, Islay.

be traced from the epidotic grits and phyllites into the gneiss, and at one locality where the gneiss is traversed by a fine-grained dyke, the one set of cleavage-planes is common to the sediments, the gneiss, and the material of the dyke. In several places, however, small fragments of the basal grits are seen adhering to the surface of one of the basic intrusions. At Carn Mor, where a basalt dyke crosses the junction, the latter bends to the north round a knot of sheared basic material. At this point and beyond the alluvium at Am Braid, where the junction-line becomes more irregular, though still running north-east, smaller inliers of gneiss and basic rock occur within the area occupied by the grits, doubtless appearing on the crests of folds which can be seen in section a little to the south at Carn Mor. The junction continues to be of this nature for the next half mile, the grits being in contact successively with the pink acid gneiss and with a sheared basic igneous rock like that seen in the road-cutting east of Kilchiaran. At a point one-quarter of a mile east of Dun Bhar-a-chlaom the outcrop bends almost at right angles and the grits transgress the bands of sheared gneissose rock, while the folding and puckering seem to continue in the same direction as that of the slate and grit already described. A considerable area of rock is here covered with peat, but the evidence favours the continuity of the sediments beneath the peat with those further to the east. An inlier of gneiss and diorite is seen in the stream three hundred yards to the east of Dun Buin Dubha, surrounded on three sides by highly epidotic grit containing pebbles of quartz and gneissose material. Rather more than a mile south of this point the junction-line between the sediments and foliated basic rocks emerges from beneath the peat and can be traced in a south-west direction for half a mile (Plate III.). Immediately south of Dun Mideir several sections show an epidotic grit charged in places with large well-rounded pebbles of gneiss, basic rock, and quartz, which have been elongated parallel to the outcrop, *i.e.*, north-east and south-west, the dip of the strata being to the south-east, at 30° to 40°. Both epidotic grit and conglomerate, and the underlying diorite, are foliated by a common set of planes more or less parallel to the junction-line, and where the pebbles are absent from the epidotic grit, it is difficult to separate the sediments from the diorite along the boundary, although a few feet from the junction the igneous character of the basic rock can easily be distinguished. About two hundred yards south-south-west of Dun Mideir the junction-line bends back upon itself and runs in an east-north-east direction, the conglomerate for a short distance following the junction, although appearing to dip below the acid gneiss with which it is sheared along the line of contact, the foliation planes in both sediments and gneiss being inclined to the south-east. A tract of peat now obscures the rocks for a short distance, but 1¼ miles east of Dun Mideir they are again exposed, and the conglomerate being gently folded or nearly horizontal, the boundary-line once more bends nearly at right angles to its former course. A large tract of peat again obscures the position of the sediments and gneiss, but to the south-east small knolls of epidotic grit and conglomerate appear at intervals for half a mile to Cnoc Thornasaig, where the junction of the conglomerate with the gneiss is once more visible, both rocks being intensely sheared and drawn out in a direction more or less parallel to the boundary. From Cnoc Thornasaig the outcrop can be followed for about one mile south-south-west towards Loch Gearach, the sheared epidotic grit being in places conglomeratic. For some distance the rocks are drift-covered, but on the roadside five hundred yards due south from the outlet of Loch Gearach the junction of the gneiss with the conglomerate is exposed in a knoll, the conglomerate here containing very large boulders of well-banded gneiss. About one hundred yards south-west of this knoll the boundary bends back upon itself, the conglomerate being once more seen on the roadside in a knoll peering through the drift. From the disposition of the gneiss the epidotic grits probably extend in a north-eastern direction.

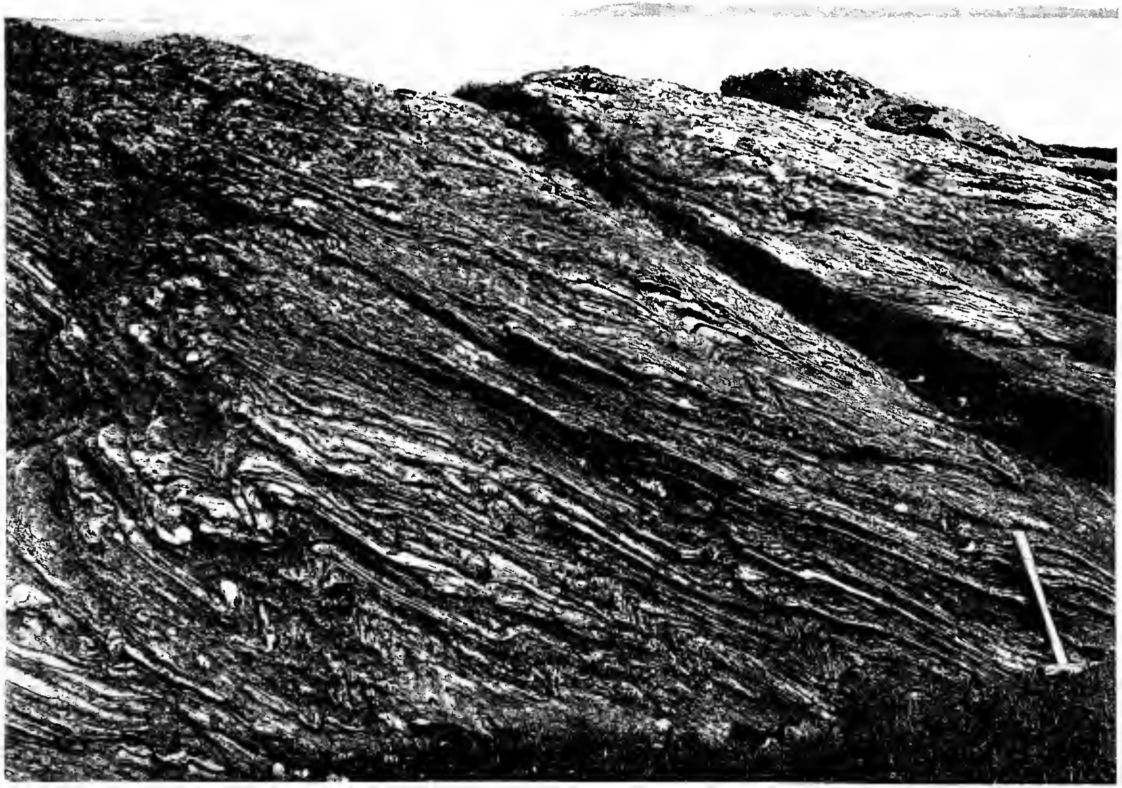
A number of pebbles from the conglomerate of Dun Mideir, 1¼ miles north-east of Kilchiaran (7006–7008), together with a specimen (7004) from one of the large boulders mentioned above, have been examined by Dr. Teall, who identified them with specimens taken from the solid rock of the gneiss area. The matrix of the conglomerate is mylonitic, with epidote and sericitic mica.

From the last-mentioned locality, near Loch Gearach, the epidotic grits extend in a northerly direction. To the south-west of Cnoc Breac, near the old road, they become very coarse, with pebbles of quartz and gneiss in a schistose matrix which has been intensely puckered and folded; the pebbles also have been flattened by the movement to which they have been subjected. These grits are repeated by a system of folds which dip in a south-east direction at about 30°. At Sunderland Farm, however, the beds are nearly flat. An outlier of these rocks, much crushed and mylonised, occurs at Port Charlotte, forming a narrow stripe about a mile in length along the shore on each side of the village. The sediments are first met with between Bruichcladdich and Port Charlotte at a point one hundred and fifty yards north of Loch Indaal Lighthouse, where an olivine dolerite dyke traverses the section and hides their junction with the gneiss. A little way from this dyke a small boss of crushed gneiss appears from beneath the mylonised sediments. The latter here consist of phyllites, slates, and sheared green epidotic grits or greywackes, the last-named being predominant. The dip of all the sediments is towards the south-east at low angles, and that of the foliation planes in much the same direction. These rocks follow the coast-line to the south of Port Charlotte, where, a little beyond the last house, their undoubted sedimentary origin is apparent, the bedding planes being still distinctly seen, while the sand grains stand out upon the weathered surfaces of the green epidotic and chloritic greywackes, which are interbedded with dark slates or phyllites. In the little bay of Port an-t-Sruthan, one-third of a mile south of Port Charlotte, sediments are seen resting upon a rounded boss of gneiss. They are green and highly epidotic, and contain boulders of banded gneiss similar to the rock with which they are in contact, masses of epidosite, and some elongated fragments of quartz which strongly resemble the pebbles of a conglomerate. The sediments continue for some little distance to the south of the burn, and similar conglomeratic beds are seen at intervals in conjunction with the gneiss. Inland the junction of the gneiss and sedimentary strata is covered by drift, but the latter do not probably extend very far westwards, as mylonitic gneiss is seen in the stream immediately behind Port Charlotte. At the south-western extremity of the Rhinns, between Portnahaven and Claddich, the coast-line, for a distance of about half a mile, is occupied by rocks which probably belong to Groups (A) and (B) of the Torridonian (Islay) Series. The evidence for this identification is, however, not altogether conclusive, the rocks having been so much altered that microscopic examination throws little light on their origin. The field evidence, however, favours this sedimentary origin. At a point about 200 yards north-west of Portnahaven the igneous gneisses are succeeded by phyllites and quartzo-micaceous rocks that resemble altered greywackes, the junction of the gneiss with the phyllites being quite sharp, and almost vertical. From this locality to Port Mias-sgeire the shore section displays phyllites and sheared greywackes altered into granulitic mica-schists, and elongated bosses of gneiss surrounded by a peculiar series of rocks consisting of epidotic schists and phyllites that contain what appear to be elongated eyes and knots of gneiss enclosed in a mylonitic matrix. All these rocks show considerable signs of movement, and it is possible that this rock may have been a conglomerate. The larger bosses of gneiss that lie to the west of this little cove are succeeded eastwards by phyllites and rocks resembling the foliated epidotic grits of Kilchiaran. In the neighbourhood of Port Mias-sgeire there are several dykes and sills of igneous rock which show a considerable amount of cleavage and distortion. The foliation planes are also much contorted, while a subsequent cleavage trending north-east and south-west cuts this contorted foliation. Most of these intrusions traverse the sediments and have been cleaved and altered together with them. These schists of presumed sedimentary origin may be the same rocks that occur at Kilchiaran and Port Charlotte. They appear to attain considerable thickness, but this is not really the case, as whenever exposed in a clear section there is seen to be a constant repetition of inverted folds, so that their true thickness is but insignificant. The axis of the folds is north-east and south-west, and the materials are all drawn out in the same direction.

B. *The Kilchiaran Slate and Grit Series.*—These slates are well exposed in several sections along the little valley between Kilchiaran Bay and Kilchiaran House, and are seen at the roadside in conjunction with the tough greyish grits of Group A in a nearly vertical position. In the north corner of Kilchiaran Bay the rock has been quarried and a rough inferior slate obtained, but the quality of the slates is not improved by the numerous north-east and south-west dykes by which they are traversed, and which were intruded prior to the cleavage of the slates. The slates form the greater part of the coast-line northwards from Kilchiaran Bay to Traigh Machir, but are interfolded in several places with the underlying epidotic grit; the largest fold of the latter occurring one-quarter of a mile south of An Gro-is-sgeir. At the northern margin of the Traigh Machir a very interesting section of the slates, traversed by igneous rocks of different ages, is seen. The area northwards to Coul Point and Coul Farmhouse is occupied by hard, tough, greenish-brown grits, separated towards their northern limit by slaty partings. These grits are not epidotic like those of the basal beds, and probably occupy a higher horizon as intercalations in the slaty group. They are repeated by a series of gentle folds, and it is probable that the grit masses further north at Saligo Bay may belong to this zone, though the evidence that this is the case is not conclusive. At Coul Point intensely crumpled slates succeed the grits, and can be traced for some distance inland over Cnoc Mor, north-east of Coul Farm. From Coul Point northwards to Saligo Bay the shore section shows bare rock, and both on the coast and on the inland side of the raised beach the slates are well developed. They are intensely puckered and cleaved, the dip of the cleavage planes being south-east, at angles varying from 30° to 75°. They are traversed by igneous intrusions of several types. On the southern shore of Saligo Bay the grits reappear, interfolded with the slates. Both rocks are cleaved, but the slaty bands have yielded to the movements in a much greater degree than the more resistent grit. Inland, to the north of Ballinaby, the same interfolding of the grits and slates continues, the cleavage planes in the slates dipping to the south-east at 40°. This alternation of slates and grits continues northwards along the coast as far as Sanaigmore, a distance of more than four miles, the slates being predominant between Saligo Bay and Rudha Lamanais; the grits to the north of that point, and between An Clachan and Tòn Mhor. Where the grits occur in mass the cliff scenery is very bold, and the folding of the beds is beautifully exposed, as at Tòn Lagain, two miles north of Saligo Bay. (See Plate I.—Frontispiece.)

The softer slates, on the other hand, are eroded by the sea into gyoes and narrow coves such as Gleann Tuath, which is filled up in a great measure with blown sand. At Coul and Saligo the rocks have been highly polished by the sand which is blown against them with terrific force. The band of grits north of Gleann Tuath forms the celebrated cliffs known as "The Sanaig Rocks." These grits are brownish in colour and highly cleaved, and alternate with calcareous flaggy bands which effervesce slightly with acid; some slate bands also occur which are also cleaved and folded. The cleavage planes dip south-east at 25° to 50°, the axis of the folding having a north-east and south-west direction. The coast-line from Sanaigmore north-eastwards to Ardnave Point affords a continuous section of slates pierced by innumerable basalt dykes. The whole of the Ardnave promontory is occupied by these slaty rocks, with thin bands of greyish grits and schistose greywackes. The rocks are all intensely puckered and repeated by folding, the

PLATE IV.



Puckered and overfolded Phyllites (Kilchiaran Series), Shore between Kilnave and Tayvullin
West side of Loch Gruinart, Islay.

axis of the folding continuing north-east and south-west, and the stretching in the same direction. To the south of the fishing station on Loch Gruinart the grits are succeeded by green schistose greywackes and phyllites with several bands of sandy limestone from one to three inches in thickness (Plate IV.).

Nave Island and Eilean Beag, lying to the north-west of Ardnave Point, are composed of the same brownish grits as the Sanaig Rocks.

S. B. W.

ORONSAY.

Kilchiaran Slates and Grits.—The solid rocks entering into Oronsay consist of an alternating series of greenish and grey slates or phyllites, and schistose felspathic grits or greywackes identical in character with those seen on the promontory of Ardnave, the northern extension of the Rhinns of Islay, of which they are doubtless a continuation. As in the latter area, these rocks are thrown into innumerable folds and puckers which are for the most part isoclinal, so that the same beds are made to occupy a wide area. Along the south and the east of the island, on both shores of the Caolas Mor, the strike is nearly north-east and south-west, while the dip of both limbs of the folds is towards the south-east at angles varying from 35°-45°. In the northern part of the island and in that part of Colonsay included in the present area, the strike is nearly east and west, and the dip of the axial planes, though generally southerly, is in some cases towards the north. These rocks are traversed in a north-east and south-east direction by a series of olivine basalt and dolerite dykes of Tertiary age.

As Oronsay is only separated from Colonsay at high tide, and these rocks are continued northwards into the larger island, their more complete description is deferred until the survey of Colonsay has been completed.

B. N. P.

C. *The Bowmore Grits.*—The rocks of this group occupy three areas round the head of Loch Indaal, which for convenience of description will be referred to under local names. The Bowmore area, on the east side of Loch Indaal, extends northwards from the mouth of the Laggan river nearly to Bridgend. The Blackrock area stretches along the head of Loch Indaal from Bridgend to Blackrock, and thence northwards to Bun-an-uillt on Loch Gruinart. Both these areas are bounded on the east by the Loch Skerrols thrust-plane. The third or Gortan area lies within the Rhinns, and consists of a small patch seen on the shore near Gortan Schoolhouse, one mile north of Bruichcladdich. It is divided from the Blackrock area by the tract of raised beach which separates Loch Indaal and Loch Gruinart. It is within this area alone that the relations of the Bowmore grits to the already described rocks of Group B can be observed, and the detailed description of this shore section will therefore be given first.

About half a mile south of Gortan Schoolhouse, dark-green slates belonging to group B are exposed on the shore. The rocks are then hidden by the raised beach northwards for about one hundred yards, when the slates reappear and continue, highly folded, for nearly one hundred yards further north along the roadside. At Braeside Cottage there is another break in the section, beyond which the slates are succeeded by tough brownish grits similar to those seen at the junction of the gneiss and sediments at Kilchiaran. Another narrow band of dark-green slates occurs at the milestone—Bridgend, 5½ miles—succeeded by tough greenish grits with veins of pinkish quartz for about one hundred yards. Up to this point all the beds described belong to Group B. The section northwards now displays felspathic brown grits with fine-grained green slaty partings, highly inclined to the south-east and much crushed. These rocks represent the passage beds into the arkoses, which come on in force just beyond the small cave 200 yards south of Gortan Schoolhouse. These arkoses are purplish-red or brown in colour and very felspathic, and, except in the greater amount of crushing and deformation that they exhibit, closely resemble the rocks of Group C seen on the shore between Uiskentui and Blackrock, two and a half miles to the east, and in the Blackrock area about to be described. The crushing of these arkcses near Gortan is quite in keeping with the phenomena observed with regard to all the rocks of the Rhinns area, with the exception of the dolerite dykes.

The Blackrock area is bounded on the west by the Gruinart Flats, on the north and east by the Loch Skerrols thrust-plane, and to the south by the raised beaches of Loch Indaal. For a distance of nearly half a mile, between Uiskentui and Blackrock, a good coast section is exposed in which the grits of the Bowmore group are seen dipping towards the east at high angles. They vary in texture from fine-grained sandstones up to grits in which the component grains are as large as peas or small beans, while some of the bands are conglomeratic. From a bed which is quarried on the shore near the western end of the section, pebbles of quartzite, quartz-schist, granite, felsite, and stained quartz were obtained, representing an assemblage of rocks identical in character with that illustrated by the pebbles of the Torridonian arkoses of Applecross, Loch Torridon, and elsewhere in the North-west Highlands. Though these rocks are very much shattered, they are less altered than the grits in the Gortan area. Microscopic examination proves that microcline is common in these grits as it is in the Torridon sandstone.

Throughout this section there is apparently a persistent dip towards the east, and though it is highly probable that the rocks are thrown into a series of isoclinal folds, the section is in the main an ascending one. Proceeding eastwards, and presumably passing upwards in the series, we find, after traversing a mile of raised beach, finer-grained and more flaggy rocks exposed in Carnaine quarry. Some beds have slaty partings, a feature also noticeable on the south-east flank of Cnoc Donn, 1½ miles to the north, and further east in the roadway under the " dry bridge " near Bridgend. These rocks also contain mica flakes, which are very rare if not altogether absent from the beds at Blackrock.

These facts seem to favour the supposition that there is an ascending order eastwards in this direction, and that these finer-grained and more flaggy beds may correspond to a portion of the Aultbea group of the north-west Highlands, which includes rocks of similar character.

Several isolated exposures of the Bowmore grits occur in the area inland from Loch Indaal. The arkoses are well seen on the crest of Borichill Mòr and along the ridge to the north, where they consist of coarse and fine-grained white weathering grits, the apparent general dip of the strata being to the south-east. A very coarse arkose also appears near the quartzite boundary at the head of Gleann Mor. Finer-grained sandstones, like those of Carnaine, are exposed in a large quarry west of Loch Skerrol near Bridgend; and on the crest of Maol na Coille and in the Bun-an-uillt stream in the northern part of the area. Along the eastern boundary of the area which is defined by the Loch Skerrols thrust-plane, the members of this sub-division are much crushed and deformed, a point to which special attention is directed in Chapter XII.

The grits occurring north of Bridgend extend southwards to the Bowmore area. For example, the hill due south of Bridgend on which the Campbell monument is situated, is formed of rocks similar to those of Carnaine quarry and the " dry bridge," already described, with the addition of one or more sills of epidiorite. These beds all dip to the south-east. At Pennycraig, under Cnoc Loisgte, rather more than a mile south of Bridgend, a purplish fine-grained grit with some slaty bands has been quarried. The rising ground of Cnoc Loisgte is formed of brown fine-grained grits, with several sills of fairly massive epidiorite, both traversed by basalt dykes. At Carnbui, south of Brobolls, the grits are more or less pebbly like those of Blackrock, and are traversed by a massive epidiorite. Similar rocks are seen at Crubach on the Port Ellen road, and on Cnoc Donn, south of Tallant Farmhouse. The shore west of Bowmore affords a continuous rock section between Rudh an' t' Saile and the mouth of the Laggan river, a distance of about four miles. The strata consist of coarse and fine-grained brown and purplish grits and arkoses. In places the rocks are a good deal crushed and disturbed; the dip of the bedding planes when undisturbed is in a south-east direction, at angles varying from 10° to 40°. At Laggan Farm, however, the dip is south-west, at 10°. The grits appear again at Bridge House and Corrary Hill along the edge of the alluvium, and at the latter place a mass of highly felspathic grit, caught up by a basalt dyke, has been converted into a dark rock (7385) with resinous lustre, showing under the microscope granular aggregates of quartz in a matrix of pale-brown glass. S. B. W.

CHAPTER VI.

SOUTHERN SERIES.

Group I.

SCHISTS, SLATES, PHYLLITES, AND LIMESTONES.

The strata included in this series fall, as indicated in Chapter III., into two distinct groups—(1) a group of slates, phyllites, and limestones ; and (2) an overlying group of quartzites with bands of conglomerate, which are regarded as the equivalents of similar rocks in the Northern Series.

We will commence with the description of the rocks of Group (1), which form two distinct belts across the south-eastern part of the island, separated by the Beinn Bhan quartzite of Group (2). For convenience of description, the belt to the north of the quartzite ridge will be referred to as the Central Belt; that to the south as the Port Ellen Belt.

This group may be further sub-divided as follows, in what is believed to be a descending order:—

iv. Blue limestone, in part oolitic (Islay limestone)—considered to be the equivalent of the Blair Atholl limestone.
iii. Black slates and phyllites, Esknish slates=Easdale slates and black schists of the Central Highlands.
ii. Grey and dark phyllites with thin calcareous beds and thin quartzose bands, "Port Ellen phyllites"=Ardrishaig phyllites (in part).
i. Quartz-schists, "Laphroaig quartz-schist" = quartzose series of the Ardrishaig phyllites, Loch Fyne.

Although some of these sub-divisions are absent from one or other of the two belts described above, yet the rocks found in the two areas, considered as a whole, fall conveniently into the four sections tabulated above.

1. *The Port Ellen Belt.*—This area extends from Alt an Daimh, on the south-west coast of the Oa peninsula, in a north-easterly direction to Carraig Mhor at the southern entrance of the Sound of Islay, a distance of about sixteen miles, its average breadth being a little over two miles; it also includes some of the islands off the south coast. With the possible exception of the Islay limestone, all the members of the series enter into the composition of this belt.

i. *Laphroaig Quartz-schists.*

The rocks of this sub-division are chiefly developed in two areas neither of which is of great extent. One of these extends along the south coast from Laphroaig, three-quarters of a mile east of Port Ellen, to Kildalton House, a distance of nearly four miles. The other lies to the north of Claggain Bay, immediately south of Carraig Mhor. There are several other small isolated patches of these rocks, and the island of Texa is also partly formed of the Laphroaig schists.

Throughout the description of this group constant reference is made to the epidiorite sills by which all the members of the series, especially in the belt under consideration, are so plentifully invaded. These masses of basic rock appear to have been injected more or less along the planes of bedding of the sediments before the latter were much moved or altered, and are consequently similarly affected by the causes to which the present plicated, deformed, and crystalline condition of the schists is due.

General Character.—The rocks of this group consist generally of reddish and grey quartzose schists or granulites containing more or less mica, chiefly biotite. They vary considerably in texture, and in some of the coarser bands traces of original pebbles of blue quartz and felspar can be detected. In some places these coarser sediments alternate either with finer-grained rocks of the same type or with phyllites. On the mainland they are, as a rule, not very schistose, but in places, especially towards their junction with the phyllites, show signs of having been much affected by movement. In the island ot Texa they appear to be more altered than on the mainland, and there assume a gneissose character. In most cases they contain more or less ferriferous carbonate, which, when decomposed, gives the rock a rusty appearance.

A good section of these rocks is exposed along the coast, one mile east of Port Ellen Post Office, and presents an alternation of sandy bands with phyllites and sills of epidiorite. About 600 yards west of Laphroaig the phyllites die out and the quartz-schists or altered sandstones become more massive. From Laphroaig Distillery eastwards the rocks are invaded by massive porphyritic epidiorites. A massive band of Laphroaig rock with blue quartz grains is seen at Surnaig Point, the western horn of Lagavulin Bay. This quartzose rock is interbedded with thin bands of phyllites and both are traversed by a thick sill of epidiorite, to whose hardening and protective influence the freedom from schistosity found in the rocks at this point is no doubt due. At the east end of this section, where the quartz-schists alternate in thin bands with phyllites, they show signs of intense movement, and are well foliated, but where in greater mass they have not given way so readily to the shearing forces. Under the Laphroaig sill the rock appears to have been hardened by the igneous rock and protected in the same manner as at Lagavulin Bay. These observations tend to show that these Laphroaig rocks are part of the same formation as the phyllites, and have been subjected to the same metamorphic conditions. The quartz-schists or altered sandstones appear to rise from beneath the phyllites in dome-shaped folds. Rocks of the nature described above form the coast-line eastwards as far as Eilean Imersay, where the quartz-schists become calcareous and contain bands of impure limestone. Ferriferous carbonates are sometimes present both in the quartzose and calcareous members of the series, and when they occur the rocks assume buff or brown colours on weathering.

The area around Ardtalla, north of Claggain Bay, is occupied by quartz-schist with folds of calcareous phyllites, and traversed by several sills of epidiorite, the margin of the quartz-schist in contact with the sills being indurated. The rocks within this area seem to be arranged in a compound anticline upon which the overlying calcareous phyllites rest in numerous minor folds. The folding is isoclinal, the strata dipping to the south-east at high angles. The coast-line northwards for about a mile from Rudha Buidhe affords a continuous section in which this constant repetition of quartz-schist, phyllite, and epidiorite is well displayed. The little stream which traverses the area about midway gives a continuous section, in which few or no bands of phyllites are visible, while on the west of the area and along the apparent strike of the beds the quartz-schists are gradually replaced by phyllites, the junction-line being a very sinuous one and the two sets of rock appearing to interlock with one another; a phenomenon doubtless due to the westerly dip of the pitch of the folds at this point. Several minor folds occur at intervals along the shore between Rudha Buidhe and Aros Bay and have also an isoclinal dip to the south-east. Between these areas and that of Laphroaig the quartzose rocks appear from beneath the phyllites along several minor folds. The largest of these masses, over half a mile in length, rises to the south-west of Loch Tallant. Their lenticular and irregular form is no doubt due to rapid isoclinal folding, to variations in the pitch of the folds, and to the effects of denudation.

ii. *Port Ellen Phyllites.*

General Character.—These rocks where least altered assume the character of well-cleaved lustrous slates; where more altered they pass into soft grey and dark sericitic mica-schist often with a silvery appearance and silky texture. In places they are calcareous, thin bands of sandy dolomitic material being a common feature in their composition. They are generally very soft and incoherent under the stroke of a hammer. The rocks are intensely folded and puckered and often filled with lenticles, veins, and reefs of quartz. Like the quartz-schists, they are pierced by numerous sills of epidiorite, and along the line of contact there is often a considerable amount of induration, through which the rock has been protected in some measure from the shearing movements to which the whole area has been subjected. The black slates and phyllites (of Group iii.) are in identically the same stage of metamorphism as the Port Ellen phyllites, and only differ from them in containing sufficient carbon, sometimes in the form of graphite, to give them their black colour. Thin intercalations of gritty quartz-schists occur in both groups (ii. and iii.).

Port Ellen Belt.—A reference to Sheets 19 and 20 shows that the Port Ellen phyllites and associated epidiorite sills occupy the greater part of the ground south of the quartzite boundary. They also form one or two narrow strips within the quartzite itself. The black slates and phyllites of Group iii. are restricted to the south-west part of the belt, where they are so intimately interfolded with the underlying Port Ellen phyllites that it has been found convenient to consider the two groups together. This area offers great facilities for the study of the strata, for not only is the coast-line a rocky one, but inland the exposures of rock are numerous, owing to the small amount of superficial deposits.

At Alt am Daimh, south-east of Beinn Môr, on the southern shore of the Oa peninsula, a band of grey puckered phyllites, a quarter of a mile broad, appears along the crest of an anticlinal fold within the quartzite area and extends in a north-eastern direction for two and a half miles, when it pitches beneath the surrounding quartzite. Towards the south-east margin of the band the phyllites are markedly graphitic, while the base of the overlying quartzite also becomes black from the amount of material derived from these schists which it contains. At Rudha nan Leacan an epidiorite sill flanks the shore for about half a mile, and at the point of contact the phyllites have been indurated, and are consequently far less crumpled than the same beds a few feet away from the intrusion. East of this point an almost continuous coast section of folded and puckered strata extends for nearly three miles. A little north of Port Ellen Lighthouse light-grey and bluish phyllites appear. They weather buff-colour and exhibit marked colour banding, due to the thin beds of decomposed carbonates which are conspicuous on the beautifully cleaved and lustrous surfaces. These beds have been quarried for slate.

At the distillery, half a mile west of the pier at Port Ellen, a very thin band of dark graphitic phyllite is separated by pebbly grits from a broader band of similar material. Numerous sections in the fields near the White Hart Hotel, Port Ellen, exhibit soft, silky, dark or grey sericite mica-schist interfolded with highly calcareous lenticular layers and thin bands of dolomitic material. The intense plication to which these phyllites have been subjected is indeed apparent in almost any natural exposure within the area. The rocks have been thrown into a rapid succession of isoclinal folds whose long axes trend east-north-east, while both limbs of the folds dip towards the south-south-east. The repetition of this folding on a large scale is shown by the relation of the phyllites to the masses of Laphroaig quartz-schist. A glance at the map at once reveals the manner in which the phyllites weave in and out amongst the boat-shaped inliers of the siliceous rock. This structure is emphasized by the behaviour of the epidiorite sills, which are more numerous in the phyllites than in the quartz-schists. Perhaps the best example of this folding is to be seen in the neighbourhood of Ardbeg, rather more than three miles east of Port Ellen. Without referring in detail at present to the quartzite, it may be well to mention here that this member of the series is involved in the same system of isoclinal folding.

On the shores of Aros Bay, near the south-east corner of the island, several thin seams of both blue and white limestone are associated with grey calcareous phyllites (Group ii.) and epidiorite sills. Although these limestone bands in many respects resemble the lower beds of the Islay limestone group, they occur along with *grey* phyllites, while the Islay limestone, on the other hand, is usually, though not invariably, associated with *black* slates or phyllites. In the absence of any recognisable member of the Islay limestone, these rocks may be considered as a possible development of some of the more calcareous beds in the Port Ellen phyllites.

The Central Belt.—The Laphroaig quartzites and quartz-schists form the only sub-division of the series that is not present in this belt of country. All the other members are both well developed and cover large areas. In this region the rocks of sub-division (ii.) consist of grey phyllites and slates, with subordinate bands of calcareous and quartzose schist. Although much corrugated, they are neither as much deformed nor in so high a stage of metamorphism as near Port Ellen. They are also invaded by epidiorite sills, but not to the same extent as in the southern belt.

Of the many localities where these rocks can be examined, the coast section along the southern side of Laggan Bay is probably one of the best. For a distance of nearly two miles between Kintraw and Rudha Mhôr the shore-line affords continuous exposures of corrugated and crumpled grey phyllites interfolded with slate bands, and constantly repeated by sharp folds, whose axes have a prevailing north-east and south-west trend. On the west side of Port Alsaig, beyond the point where the shore is determined for some 300 yards by a dolerite dyke, the phyllites become highly calcareous and contain many thin bands of coarse sandy dolomite. These weather with a buff or ochreous colour, and present a carious appearance from the dissolving-out of the dolomite crystals. The calcareous bands appear along the cliff face westwards for 500 yards, where the beds are highly puckered, and are followed by grey phyllites which form the cliff for about 300 yards. The calcareous schists then reappear, intensely folded and veined with calcite, and in the neighbourhood of the fault which brings down the quartzite on the west, much jointed, shattered, and brecciated. The rocks in this section seem to be identical in character with the strata around Port Ellen and in Eilean Imersay near Kildalton Castle. Inland from the coast, frequent exposures of the phyllites show that this intense folding prevails throughout the area.

Another admirable coast section extends from Dun Mòr Ghil, at the southern extremity of the quartzite outlier, round the Mull of Oa to Port nan Gallon. For 1½ miles southwards the rocks are similar in character and sequence to those of the Kintraw section just described, and display the same intense folding and corrugation. At Rudha Leac nan Laogh, half a mile north of Mull of Oa, purer and more massive limestones are intercalated with the schists. These are considered to be the lower beds of the Islay limestone.

The remaining portion of the section, from the magnificent cliffs of the Mull of Oa to Port nan Gallan, presents a succession of phyllites and schists with dolomitic bands and occasional infolds of Islay limestone. At Bruthach Mhòr both the dolomite and the limestone can be seen, the former weathering with a bright ochreous colour.

Excellent sections of the phyllites are exposed in the Torra and Glenegedale rivers and in the smaller streams that flow down the western slopes of the quartzite ridge.

Between Bridgend and Ballygrant the black slates of subdivision (iii.) are largely developed, and were formerly extensively quarried at Esknish, where they show beautiful surface colour-banding. and often contain large cubes of iron pyrites. In the districts of Ballygrant, Finlaggan, Lossit, and Mulreesh frequent exposures of black slate are seen. The river Sorn has cut a deep gorge through the phyllites along the lower part of its course, and in the ravine near the cloth-mill these rocks are seen to be closely interfolded with the Islay limestone.

iv. *Islay Limestone.*

General Character.—Where the rocks have not been subjected to much movement, the Islay limestone is a more or less massively bedded rock, the less massive type sometimes passing into a flaggy limestone. In texture it is fine-grained, and varies in colour from dark-blue to grey and yellowish-white, with blue and white bands. Oolitic structure has been observed in some of the beds, and with a few exceptions these oolitic bands are found in all parts of the island where the limestone occurs.

The Central Belt.—An important feature connected with the distribution of the Islay limestone is that it is confined to the central belt, where it has a remarkable development, especially in the north-eastern area between Bridgend and Portaskaig. In the Oa peninsula the calcareous rock generally occurs in thin bands interfolded with the underlying phyllites; the axes of the folds having the general south-west and north-east trend common throughout the island. At Port nan Gallan, bands of rapidly folded dark limestone are seen in the cliff section. The narrow lenticular folds of the limestone extend in a north-easterly direction, the rock appearing at intervals near the crofts of Kinnabus and Coillabus—where some of the oolitic beds occur—and in other localities northwards to the Allt nan Airidhean. A short distance beyond that stream the limestone band appears to strike directly at the quartzite and passes underneath that formation. At a point one mile north-north-east of Castlehill Farmhouse, at the east margin of a wide tract of peat, a similar relation between the limestone and quartzite can be observed, and half a mile further to the north on Maol Airidh a Dhuin, a thin limestone band interfolded with the phyllites is unconformably overlaid by the quartzite.

In the wide stretch of ground covered with superficial deposits that lies between the western margin of the quartzite range and the shores of Laggan Bay, there is only one exposure of limestone, where the rock has been quarried on the west side of the Bowmore road, 600 yards south of the Duich river. It is a dark-blue compact rock, and is much folded. To the west of Beinn Bhan a narrow band of the same rock appears at short intervals near the margin of the quartzite. At the Uillt Ruadha a large mass of sharply-folded limestone is directly overlaid by the Portaskaig conglomerate. In the area drained by the upper waters of the Laggan and Kilennan rivers limestone is also intensely interfolded with the phyllites. The plicated mass has been denuded at different levels, leaving innumerable lenticular and irregularly-shaped masses of limestone, while in some cases the crests of the folds of the limestone only have been removed, leaving inliers of the underlying dark phyllite surrounded by the limestone. This structure is very apparent to the west of Loch Allallaidh, where the limestone is spread over a large area.

The oolitic bands in the limestone are largely developed in this locality. At a point within the western margin of the limestone area, three-quarters of a mile west-north-west from Loch Allallaidh, and a few yards south of an epidiorite sill, this structure is particularly well seen. The oolitic grains are dark, nearly spherical bodies, and measure about three-sixteenths of an inch in diameter. Examination of these spheroids under the microscope show that they are composed of crystalline calcite. The grains which form the ooliths are distinctly larger than those of the matrix, and show, moreover, a concentric structure due to the arrangement of dark particles; this structure being in many cases independent of that due to the crystalline character of the rock. In the peripheral portions of some of the ooliths the individual grains of calcite are longer in a tangential than in a radial direction.

The relations of the limestone and phyllites in the folded region around Storakaig and Loch Bharradail, in the south-east corner of Sheet 27, show clearly that the latter are the older of the two rocks. Inliers of phyllite occur within the limestone to the east of Loch Fada, at and near Baleachdrach; while at the head of Glen Logan there are many outliers of limestone resting in synclinal basins upon the underlying phyllites.

At Persabus, about a mile west of Portaskaig, somewhat massive grey and dark-blue oolitic limestone is exposed in the quarry one hundred yards to the east of the road up to the farmhouse. A specimen from this quarry is composed of "dark spots of the size and form of oolitic grains embedded in a lighter-coloured matrix. Under the microscope the rock appears as a crystalline granular aggregate of calcite, and there is no marked difference between the oval sections of the supposed oolitic grains and the matrix so far as the form and size of the constituent grains of calcite are concerned.

The difference lies in the fact that minute opaque (? carbonaceous) particles are more abundant in the calcite which forms the grains than in that of the matrix. If the oval grains were originally oolitic, as there seems no reason to doubt, they must have undergone recrystallisation."

At a point rather less than a mile east of Bridgend, on the Portaskaig road, the limestone has been worked for many years in a large quarry where the rock is less disturbed than elsewhere in the area. The bedding is rather massive, and some of the beds are extremely fine-grained and close in texture, the general colour varying from blue to pale-grey. This stone has been largely burnt for lime, for which purpose it is excellently adapted.

The farm of Tallant, two miles to the south-east of Bowmore, stands upon an outcrop of limestone which forms a slight hollow feature between the Portaskaig conglomerate on the one side and the Torridon sandstone on the other; the Islay limestone being brought into contact with the latter by a fault with downthrow to the west.

Group II.

BEINN BHAN QUARTZITE AND CONGLOMERATE.

The quartzite and conglomerate included in the Southern Series of the two main divisions into which the metamorphic rocks of the eastern area have been thrown, extend across the south-eastern portion of the island from the Mull of Oa to the Sound of Islay at a point two miles south of Portaskaig. This belt of rock, which widens gradually from Port Ellen to the north-east, forms the principal watershed and contains most of the highest hills of the island.

Isolated areas or outliers of the typical quartzite occur along the north-west coast of the Oa promontory, and on the western flanks of Beinn Bhan, 4½ miles south-east of Bowmore. Portions of the Ardmore promontory on the south-east coast of Islay and of the adjacent islands are also formed of a rock which has a close resemblance to the quartzite of the main outcrop, and may represent isolated folds of that formation. This correlation cannot, however, be conclusively proved, and it is possible that the Ardmore quartzite may represent the siliceous bands not uncommon in the Ardrishaig phyllites of the mainland.

The quartzites of this series represent a higher phase of metamorphism than that found in the northern portion of the island; but otherwise in general character and grouping resemble those of the Northern Series. They are, as a whole, granulitic, only the cores of the larger pebbles, which are often composed of the blue quartz so abundant in the quartzite of the northern area, having escaped granulitisation.

Although the rocks are in general considerably deformed, ripple marks are still retained on some of the surfaces, and at one locality, one-third of a mile north-north-west of the summit of Beinn Bhan, not far beneath a sill of epidiorite, annelid borings, similar to those found in the northern area, have been detected. The horizon of this zone of "piped" quartzite has not been definitely ascertained.

At certain localities along the western margin of the main belt a basal conglomerate occurs, which, both in general character and in the pebbles which it contains, closely resembles the Portaskaig conglomerate of the Northern Series, of which it is considered to be the equivalent.

At the south-eastern margin of this quartzite there is always present a pebbly or conglomeratic band, which, in addition to well-rounded quartz pebbles, often contains large fragments of the immediately underlying rocks. It is, however, wholly different from the conglomerate of the north-west margin, and bears a strong resemblance to the beds forming the southern margin of the Perthshire quartzite, as described in the Memoir accompanying Sheet 55.

Proceeding now to the relations of the Beinn Bhan quartzite to the strata on either side which are regarded as of older date, we will describe first of all certain sections along the south-east margin, where the quartzite is in contact with the Port Ellen belt of phyllites, limestones, and quartz-schists.

Junction of the Beinn Bhan Quartzite with the Port Ellen Belt.—The nature of the relations between the quartzite and the underlying phyllites along the south-eastern boundary of the former rock being an important point in the structure of the island, it is proposed to discuss those sections where the best exposures of the junction may be found in more detail than was given in the section dealing with the Port Ellen phyllites.

Excellent sections may be observed at three localities—viz., at a point one-quarter of a mile east of Beinn Mor, almost the most southern point on the Oa promontory; along the coast west from Port Ellen to a point a little south of Port Ellen Lighthouse; and on the east coast, where the rocks are exposed on the shore one mile north-north-east of Ardtalla farmhouse. About 440 yards east of Beinn Mor a sandy shale occurs which is not unlike the matrix of the Portaskaig conglomerate, but contains no pebbles; this being succeeded eastwards by contorted and cleaved leaden-coloured schists and phyllites. At the eastern end of Allt an Damh the phyllites are graphitic and enclose a bed of pebbly quartzite or conglomerate in which are pebbles of quartzite two inches long and fragments of graphitic phyllite several inches in diameter; the matrix of the grit being rendered bluish-black in colour by the amount of derived carbonaceous matter it contains. There can be little doubt that the quartzite is here resting in a synclinal fold of the phyllites. About 50 yards further to the east similar grits reappear, forming a band over 200 yards in breadth. The marginal phenomena and included fragments are here the same as in the case just described. This band of grit is highly conglomeratic, and on the hill-top particularly coarse, some of the fragments of graphitic schist being a foot in diameter. Along the line of junction to the north-east the two sets of rocks are so intensely sheared and folded together that their mutual relations cannot be determined.

In the shore section west of Port Ellen the alternation of quartzite and phyllite due to the constant interfolding of an upper and lower set of strata is also well expressed. At the eastern end of the section thin lenticular bands of dark phyllite or black schist appear within the pebbly quartzite, being brought up upon the crests of sharp anticlinal folds. The broader bands of the phyllite, on the other hand, surround isolated "boat-shaped" masses of the same pebbly grit or quartzite underneath which the phyllites dip on every side. A band of coarse pebbly grit can be traced around the margin of one of these masses a short distance east of the distillery pier, and it is evident that the quartzite is resting in synclinal folds upon the underlying phyllite, the isolation of each mass being due to change in the pitch of the folds. The lenticular masses of conglomerate which occur close to the edge of the main quartzite area further to the west are chiefly made up of pebbles of blue and white quartz, with a few larger individuals of quartzite. Fragments of dark slate and phyllite are also included in the conglomerate and the grit with which it occurs. The pebbles of quartzite may have been derived from the thin intercalations of quartz-schist in the Port Ellen phyllites to which reference has already been made.

Between Kilnaughton Bay and the lighthouse there follows a constant succession of quartzites and pebbly bands which are all more or less sheared. At the slate quarry, a little north of the lighthouse, the signs of shearing are still more pronounced, the strata being converted into quartz-schist, whose divisional planes are coated with a pellicle of sericitic mica and in some instances of acicular crystals of (?) andalusite. Dr. Teall describes a specimen from this locality as follows:—(7575) "This rock is not a quartzite. It can be easily scratched with a knife. The main mass is a confused aggregate of minute scales of white mica. There are also a few grains of tourmaline and some relics of what appear to be crystals of andalusite."

Beyond the colour-banded grey and bluish phyllites of the quarry, pebbly grits, not so much sheared as on the north side of the quarry, reappear, and from this point to the lighthouse there is a constant repetition of pebbly grit and phyllites. At the base of the little promontory on which the lighthouse is placed the phyllites rise from beneath the pebbly quartzite in an elongated dome. When followed along the long axis of the fold the phyllites are seen to dip under the pebbly quartzites, the alternation just referred to being evidently due to the folding of the two groups of strata.

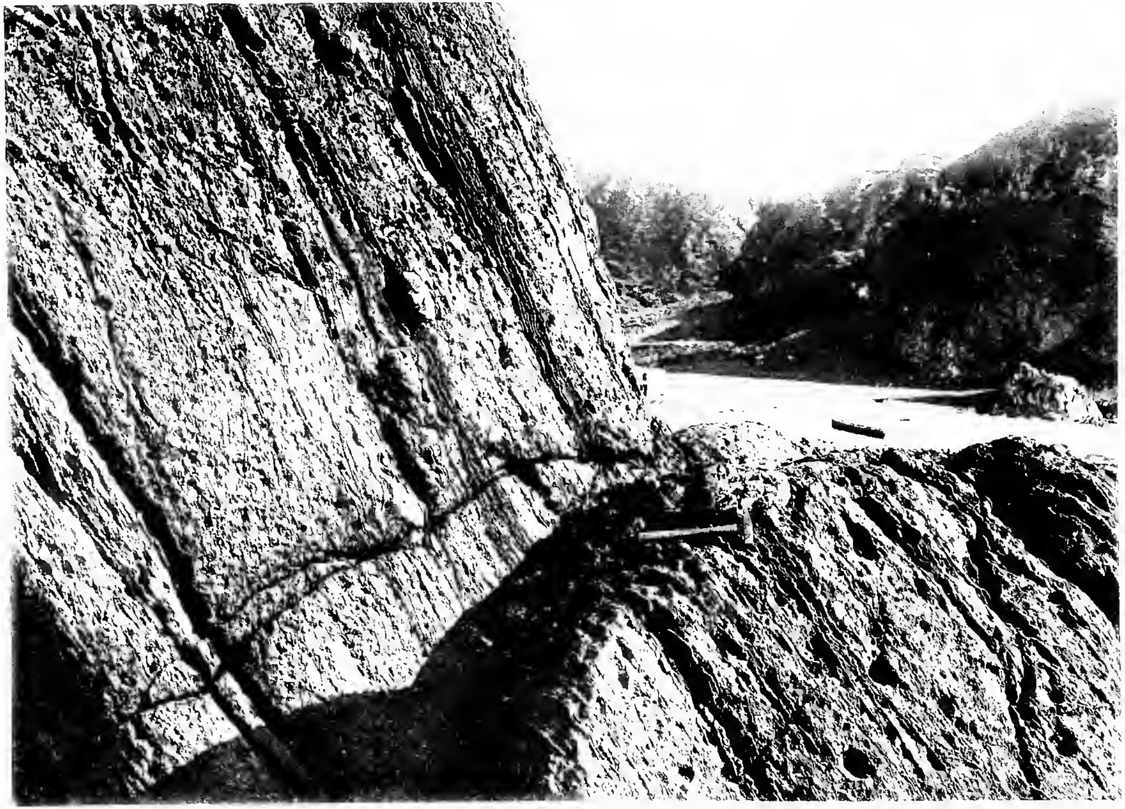
From this point along the coast-line to the south-west there is a constant repetition of these two sets of beds. The grits are often highly conglomeratic and in places contain numerous fragments of phyllite and calcareous sandy rock. Near Alt na Albannaich the phyllites are in broader bands than the grits, which can be seen to occupy synclinal folds in the former. There is evidence of intense folding, puckering, and shearing and more than one set of cleavage planes both in the quartzite and phyllites, but more especially in the latter. It is impossible to infer from the evidence afforded by these sections what may have been the original relations of these rocks to one another. Many of the beds which are associated with the pebbly grit and conglomerate remind one of the matrix of the Portaskaig conglomerate, but as far as observed contain not a single pebble of limestone, granite, or gneiss.

The last section to be described is exposed on the shore west of Carraig Mhor and one mile north-north-west of Ardtalla farmhouse at the north-east end of the Port Ellen belt. North of the little stream, a band of conglomerate crossed by a dolerite dyke appears from beneath the drift at intervals for a distance of one hundred yards till it reaches the sea. This conglomerate contains pebbles of limestone six inches across, grains and pebbles of blue and white quartz, and fragments of shale, quartzite, and grit, set in a sandy red matrix. Numerous fragments of felspar and one small piece of a felsitic rock also occur. The blue quartz and the felspar may have been derived from a granite like that found in the Portaskaig conglomerate. At a point 40 yards north of the dolerite dyke the quartzites reappear, the junction with the phyllites being abrupt and the quartzite very pebbly. The phyllites are again brought up on an anticlinal fold to the north of this point, and have been eroded into a hollow recess of which the pebbly quartzites form the northern wall; the fold of phyllite thinning out as it is traced up the cliff. Further north the pebbly quartzite alternates with narrow bands of phyllite that appear on the crests of successive sharp folds. The latter eventually disappears and the coast-line is formed of folded quartzite. One of these bands of pebbly quartzite is almost black from the amount of included fragments of graphitic schist.

Junction of the Beinn Bhan Quartzite with the Phyllites, Slates, and Limestones of the Central Belt.—The conglomerate which is locally developed at the base of the quartzite occurs in isolated and often widely separated patches along the western margin of the quartzite belt. The chief area lies on the north-western slopes of Beinn Bhan. Others are found between that mountain and Cnoc na tri-dail; at Balvicar, two miles north-west of Port Ellen; around Risabus Manse and Loch Ardachie; and on the Oa promontory, extending inland from the coast at Port nan Gallan.

The stream of the Uillt Ruadha, which has cut deeply into the slope of Beinn Bhan, affords good rock sections in which the conglomerate is seen resting both upon the Islay limestone and the dark phyllites. The conglomerate is red in colour and at this point contains numerous intercalated bands of flaggy quartzite, the pebbles not being abundant. A short distance from the stream, however, the rock is charged with fragments of quartz-schist, limestone, granite, and hornblende-schist, some of the boulders being over one foot in diameter. A section of a similar coarse pebbly conglomerate is exposed further to the east in one of

PLATE V.



Basal Conglomerate (Southern Series), Port Nan Gallon, Mull of Oa, Islay.

the higher tributaries of the Kilennan river. Here the conglomerate can be followed up the stream for 250 yards, when it is succeeded by hard white quartzite dipping south at 30°.

Several small exposures of conglomerate and sandy and dolomitic shales with scattered limestone pebbles are seen at Balvicar, $1\frac{3}{4}$ miles north-west of Port Ellen, and in the neighbourhood of Risabus Manse, two miles further to the south-west. These sections are sufficient to indicate that the conglomerate, although slightly represented, occupies its usual position with regard to the limestone and the quartzite.

The relations of the conglomerate to the underlying phyllite and Islay limestones and to the overlying quartzite can be studied to great advantage at Port nan Gallan, one mile east from the Mull of Oa. This little cove is bounded on the north and south by bold rugged cliffs, and on the east by a small area of raised beach, above which rises the old sea cliff in which the strata are well exposed. To the north of the cove are seen the blue Islay limestones, sharply interfolded with the phyllites.

The two diagrams below will help to illustrate the relations of the strata to one another as seen in Port nan Gallan shore sections. (Figs. 2 and 3.)

These are all seen in the little stack or pinnacle which is partly surrounded by water at high tide. Between tide marks the rocks still dip to the south-east, and occur in the following order, southwards. First we find sandy calcareous beds with occasional pebbles (16 feet) similar to those of Portaskaig. At this point there seems to be a fault crossing the strike. For the next 22 feet the beds exposed on the shore consist of sandy quartzose calcareous rock with scattered pebbles, and occasional beds of pure quartzite, the last few feet being composed of such material, dipping south-south-east at 50° to 60°. Next in order come 27 feet of sandy calcareous shales with rusty weathering, containing large blocks of granite and quartzite. Beyond this point the rocks are concealed near low-water mark under coarse beach material for a distance of 45 feet, but near high-water mark an almost continuous section is exposed, where similar conglomeratic beds appear with a rusty sandy matrix. Southwards they pass under beds of calcareous quartzite.

At a distance of 45 feet from the conglomerate these quartzites contain large rounded pebbles of granite and other rocks. The dip of all the strata is in the same direction and at about the same angle, and there is an insensible passage of these conglomeratic beds up into the pure quartzite which occupies the shore for the next 132 feet. The beds are next truncated obliquely by a line of fault. From this point to the base of the cliff which bounds the south of the bay, the rocks consist of quartzite, and the cliff is made of the same material. In the south-east angle of the cove, a fault brings the Portaskaig conglomerate into contact with the quartzite, and the fault breccia is well seen in the side of a little gully up which there is a path to the top of the cliff.

Consideration of the above section points strongly to the conclusion that the conglomerate, which in its mode of occurrence, its matrix, and its pebbles is identical with that of Portaskaig, here rests unconformably upon the Islay limestone series, and passes up insensibly into the quartzite. It is impossible to estimate with any degree of exactness the thickness of the quartzite.

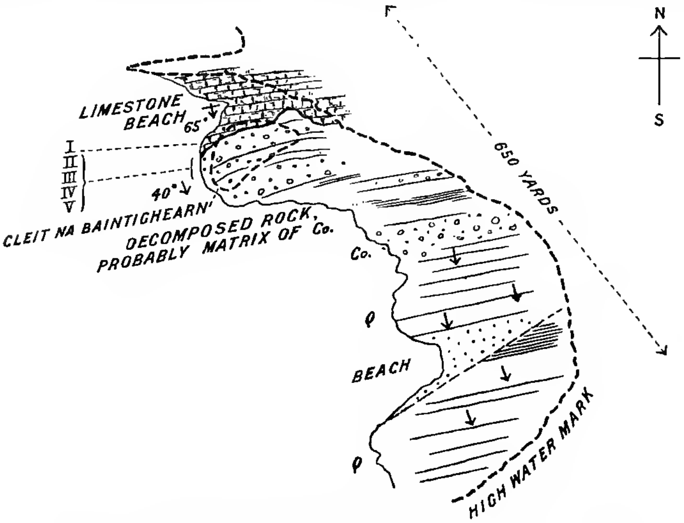


Fig. 2.—Plan of Shore Section, Port nan Gallan, one mile east of the Mull of Oa.

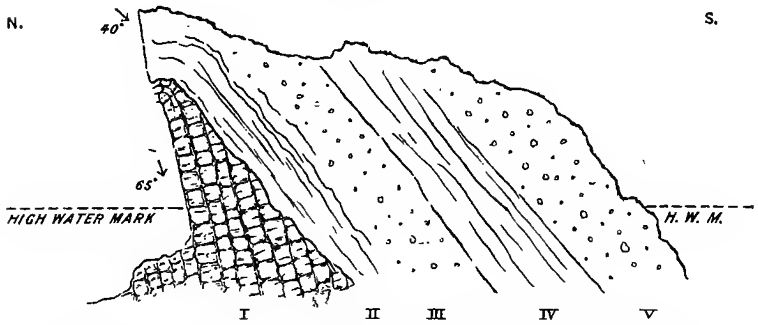


Fig. 3.—Section of Strata at Cleit na Baintighearn, Port nan Gallan.

I. Limestone in thin bands, reddened and bleached.
II. 4 ft. 7 in. sandy calcareous band with a few lenticular fragments of rusty limestone.
III. 4 ft. 7 in. sandy bed with numerous limestone fragments (pebbles).
IV. 9 ft. 6 in. sandy calcareous beds with no pebbles.
V. 13 ft. sandy calcareous rocks, containing large pebbles of granite with blue quartz, also pebbles of quartzite and limestone.

The impression of enormous thickness conveyed by the apparent undisturbed appearance of the rock and regular dip of the bedding planes is misleading. On closer examination it is found that the beds have been repeated by a system of isoclinal folds, and as it is only occasionally that the crests of these folds can be detected, the strata appear to have a uniform dip in the same direction, thus giving this deceptive appearance of great thickness.

The intense plication of the rocks of this group is well displayed on the hill-slope one mile west of the summit of Sgor nam Faoileann, where the isoclinally-folded beds of quartzite are truncated by a fault or thrust-plane, and are seen to rest upon nearly vertical limestones and phyllites.

The isolated strip of quartzite which fringes the coast-line and forms the fine line of cliff along the north-western sea-front of the Oa promontory, has been brought down against the phyllites and limestones in the east by a fault with a downthrow to the west.

The quartzite of this area is in general a massive thick-bedded rock with occasional flaggy beds, white in colour, and exceedingly fine in grain. Along the eastern faulted boundary the rocks are very much shattered and brecciated. On the north-western slopes of Beinn Bhan, east by south of Bowmore, there are several outlying lenticular masses of quartzite which closely resemble the rock of the main area, and probably represent the remains of denuded folds of that formation.

Three-quarters of a mile west of the summit cairn of Beinn Bhan, and immediately to the north-west of a small nameless lochan, there is a lenticular area, 700 yards in length, within the quartzite belt in which are a series of small exposures of rusty shale and massive cream-coloured dolomite. This area has not been differentiated on Sheet 19 from the underlying phyllite and limestone group, but the evidence obtained in the northern part of Islay (Sheet 27) after the publication of Sheet 19, suggests that these rocks may probably be the equivalents of the shales and dolomite of the highest subdivisions (5) of the Northern Series, to which they are closely similar in lithological character.

This correlation is strengthened by the occurrence at no great distance—the interval being concealed by peat and drift—of a small exposure of white ripple-marked quartzite with annelid "pipes" referable to sub-division (4) of the same series.

An isolated area of quartzite occurs along the shore stretching south-west from Ardmore Point, the south-eastern headland of Islay. At a point on the coast three-quarters of a mile south-west of Ardmore farmhouse (Sheet 20), large boulders and pebbles of dolomite or limestone are embedded in a typical quartzite matrix. The limestone has often weathered out, leaving sometimes a cavity, in other cases it has only partially dissolved, giving the rock a very peculiar honeycombed appearance. This mass of quartzite may either be a fold or outlier of the main mass, or it may belong to the phyllite series.

Quartzite of Jura.—The quartzites of this series pass across the Sound of Islay and form the small portion of Jura which is included in Sheet 27. As practically the whole of that island is composed of this rock, the description of the Jura quartzite will be deferred, and given in the explanation accompanying the sheet in which the greater part of that island is represented. S. B. W.

CHAPTER VII.

METAMORPHIC ROCKS OF THE NORTHERN SERIES.

We will now proceed to the description of the rocks of the Northern Series, which occupy the north-eastern portion of the island between the Loch Skerrols thrust-plane and the Sound of Islay. They are found to comprise the five groups or sub-divisions given below in descending order:—

5. Sandy shales or flags with ripple-marks and worm-casts, resembling the "Fucoid beds" of Sutherland and Ross; with massive beds of cream-coloured dolomite.
4. False-bedded blue and white quartzite with ripple-marks and vertical annelid borings—"pipes"—thickness 100 feet.
3. Sandy, rusty, ripple-marked and worm-tracked shales and flags, with dolomitic shales and an occasional band of dolomite.
2. Quartzites with a band of conglomerate (upper boulder bed) locally developed near the top, containing well-rounded pebbles of granite and other rocks, similar to those in the Portaskaig conglomerate.
1. Portaskaig conglomerate (lower boulder bed), charged with well-rounded pebbles of granite, gneiss, quartzite, limestone, &c., in a sandy dolomitic and sometimes shaly matrix; with intercalations of green sandy shale, quartzite, and rusty-weathering dolomite.

It is worthy of note that sixty-nine specimens of calcareous rocks from Groups 1 and 5 of the foregoing table and from the Islay limestone, were tested by Dr. Pollard, who found that the bands in Groups 1 and 5 are dolomites, while those associated with the slates beneath the Portaskaig conglomerates are limestones.

Before describing the distribution and relations of these sub-divisions, brief reference may be made to some of their prominent lithological characters.

Group 1.—The Portaskaig conglomerate, so called from its being most typically developed in the neighbourhood of Portaskaig, on the Sound of Islay, has generally a sandy, dolomitic, or sometimes shaly matrix. Intercalated in varying abundance with the conglomerate are bands of rusty-weathering dolomite and quartzite. In certain localities it is entirely calcareous, being made up of grains and large fragments of the Islay limestone.

The fragments with which this conglomerate is charged represent nearly all the formations found in the island. They include pebbles of gneiss resembling that from the Rhinns of Islay; of sandstone and grits like Torridon arkose; quartz-schist, probably derived from the schists of Laphroaig or from the quartzose bands in the phyllite series, hornblende-schist and epidiorite, and large boulders of a brilliant red granite whose origin is unknown. Pebbles and boulders of the Islay limestone, including fragments from the oolitic beds, are also very numerous. The conglomerate is thus proved to be younger than most of the rocks represented on the island.

Group 2.—The quartzite included in this series ranges in texture and composition from a coarse felspathic pebbly grit through a massive fine-grained purely siliceous quartzite to a flaggy impure rock which might be described as a sandy phyllite. A large proportion of the grains and pebbles in the rock are composed of blue quartz.

Over the greater part of the area the rock shows little or no signs of movement, but in the neighbourhood of the Skerrols thrust-plane it is much drawn out and mylonized; while in other localities it is slightly granulitic with a large amount of sericitic mica developed on the divisional planes.

False-bedding is common, and the surfaces of the flaggy finer-grained beds are often well ripple-marked.

A massive conglomerate with a quartzite matrix occurs frequently in the northern area at or near the top of the quartzite formation, and separated from the Portaskaig conglomerate by several hundred feet of quartzite. It is charged with boulders and pebbles similar to those found in the Portaskaig conglomerate. It is largely developed on the flanks of Giur Bheinn by a system of gentle folds, while to the south-west of that mountain long tongue-shaped areas extend in a south-westerly direction. This band of conglomerate, together with the "pipe"-bearing band of quartzite (No. 4) and the Portaskaig conglomerate, mark three well-defined horizons which have proved of great service in unravelling the complicated structure of this region.

S. B. W.

Group 3.—The rocks entering into this group consist of about 40 feet of grey silky shales or slates at the base, succeeded by a somewhat greater thickness of dolomitic flags with one or more bands of dolomite. In the south of the area there is only one thin band, but in the north part of it there appear to be more, and one band of cream-coloured dolomite is thick enough to be shown on the map. Some of the sandy shales show sun-cracked and ripple-marked surfaces and are occasionally covered with worm-casts *(Planolites).*

B. N. P.

Group 4.—A peculiar and well-marked band of quartzite, about one hundred feet in thickness, occurs near the base of the "fucoid" beds (Group 5). It is a very close-grained rock, nearly pure white, with tints of blue and rose colour, and often false-bedded. It frequently contains "pipes" or annelid tubes in great abundance, and on at least one bed ripple-mark is clearly defined. The so-called "pipes"—*Arenicolites* of British and *Scolithus* of American geologists—are of three distinct kinds, and are exactly similar to those which characterise three of the zones into which the upper part of the Cambrian quartzite or "pipe rock" of the North-west Highlands has been divided by the Geological Survey, viz., the "small pipes" characteristic of Zone I., the "ordinary pipes" of Zone II., and the "trumpet pipes" of Zone III. of that formation. In describing the structure of the northern part of the island, this band of pipe-bearing quartzite will be frequently referred to. B. N. P.

Group 5.—The band of "piped" quartzite described above is overlaid by and constantly seen in contact with the rocks of Group 5. The sandy shales and flags with worm-tracks, and massive beds of cream-coloured dolomite of this sub-division, spread east and west for a considerable distance, covering a large area of ground. The rocks of this group, as seen on the shore sections of the Sound of Islay, where they are best exposed, consist in the main of greenish-grey and black shales with alternations of yellow sandy or gritty bands, and several bands of cream-coloured or white dolomitic limestone, some of which attain a thickness of upwards of ten feet. The whole of the strata are more or less dolomitic in character. Many of the finer-grained beds show sun-cracked and ripple-marked surfaces, which, at several horizons, are covered with flattened worm-casts *(Planolites)* exactly similar to the so-called fucoid impressions which give their name to the "Fucoid beds" of the Cambrian formation in the North-west Highlands.

RELATIONS OF THE PORTASKAIG CONGLOMERATE TO THE PHYLLITES, SLATES, AND LIMESTONES OF THE CENTRAL BELT.

While there is no evidence of a violent unconformity between the Portaskaig conglomerate and the rocks upon which it is seen to rest, or that the interval of time between the formation of the Islay limestone and phyllite group and deposition of the conglomerate was of very great extent, distinct proof can be brought forward in several areas of the trangression of the conglomerate over different members of the underlying group. This transgression seems, however, to be due to local erosion and the deposition of the conglomerate on the partially denuded surface, so that it rests now upon the limestone, now upon the underlying black phyllites from which the limestone has been removed. That the Portaskaig conglomerate and the quartzite form integral parts of the same formation is at once apparent in the neighbourhood of Portaskaig, where the intercalation of quartzite beds in the conglomerate and the natural passage of the latter upwards into the quartzite are plainly seen. Wherever the three groups, viz., (a) Islay limestone and associated phyllites, (b) Portaskaig conglomerate, (c) Quartzite, are seen together over this wide area in a natural section, undisturbed by faulting or thrusting, the conglomerate with its derived pebbles from the older rocks is invariably found to maintain its position above the limestone-phyllite series and below the quartzite.

The Portaskaig conglomerate has a wide distribution in Sheet 27. The principal area occurs along the shores of the Sound of Islay to the north and south of Portaskaig, where it forms a band less than a mile in width and rather over two miles in length. The conglomerate also covers a considerable tract along the north-western slopes of the valley of the Sorn, between Loch Skerrols and Loch Finlaggan. A smaller patch forms the higher ground between Torrabolls and Ardnahoe, and extends to the shore of the Sound, while small outliers occur around Persabus and on the hill of Beannan Dubh, above Loch Lossit.

The area on the east coast of Islay, north and south of Portaskaig, where this conglomerate is typically developed, extends southward from a point close to the Caol Ila distillery to Am Meall, south of Portaskaig. Along the entire length of this coast section the Portaskaig conglomerate with its bands of interbedded quartzite can be examined. At a point on the shore, exactly five hundred and fifty yards north of Portaskaig, a band of cleaved flaggy quartzite with occasional pebbles of limestone occurs in the conglomerate. One hundred yards south of the last locality several beds of grey and white gritty quartzite, dipping north-north-west at 25°, are underlain by sandy shales with another quartzite band containing small scattered pebbles. From this point to Portaskaig pier the rock is of the usual type, showing a cleaved reddish matrix with large boulders of red granite, limestone, and quartz-schist. At the cliff west of the pier sharply-folded bands of hard, grey, rather flaggy quartzite occur. For some distance to the south the usual type of reddish-grey conglomerate is seen, the matrix often showing evidence of cleavage. Intercalated bands of the harder quartzite show the true dip of the strata to be north-west, at angles varying from 30° to 40°, the dip of the cleavage planes being in the same direction at 23° to 45°. To the north of the little burn, one hundred and fifty yards north of Ruadha Port-an-t-Seilich, the direction of dip changes to south-south-east, and a little inland, south of the same burn, it is due east at 20°. Four hundred yards south of Ruadha Port-an-t-Seilich the inclination of the strata, as shown by the quartzite bands, is again to the north-west at 28°.

The intercalation of quartzite bands with the conglomerate is also clearly visible in many inland sections up to the western boundary of the conglomerate area. At Ballochroy, west of Portaskaig; on Creagan Loisgte, two miles to the south and at several intermediate points, bands of fine-grained, often flaggy, quartzite are intercalated with the typical red sandy conglomerate of Portaskaig filled with the usual pebbles, those of limestone being particularly abundant at Creagan Loisgte.

Along the southern margin of this belt, from Am Meall, a point on the coast two miles south of Portaskaig pier, westwards by the ancient fort of Dun Bhoraraic to Lossit Farmhouse, the conglomerate overlies different members of the older series. For example, north of the last of these localities, the conglomerate with its numerous bands of rusty-weathering dolomite, is constantly seen resting—now on the Islay limestone, now upon inliers of the dark phyllites. At many points in this locality the dolomitic bands of the conglomerate and the Islay limestone are almost in contact, and are often difficult to separate in the field. Chemical analysis, however, shows that the blue rock is invariably a pure limestone, the rusty-weathering rock a dolomite. Again on the hill of Beannan Dubh, which overlooks Loch Lossit on the east, a plateau-shaped outlier of conglomerate with intercalated dolomite bands clearly overlies the Islay limestone.

The western boundary of this belt of conglomerate is, for the greater part of its length, a line of fault, but one of small magnitude, which runs south from Torrabolls farm by the old ruins of Kilslevan Chapel to near Lossit farmhouse.

Along its northern limit the conglomerate passes naturally upwards into the quartzite (Group 2), the sequence being visible on the shore at Caol Ila Distillery.

Another mass of the Portaskaig conglomerate lies a mile and a half to the north of Portaskaig between Ardnahoe and Torrabolls (Sheet 27). Its northern boundary may be defined as a line running through the centre of Ardnahoe Loch in a north-east direction to the Sound of Islay, at a point three-quarters of a mile south of Rudh' a' Mhill. It is bounded on the south for a distance of three hundred and fifty yards by the fault described as determining the western margin of the Portaskaig area, and further extends in a westerly direction with a very sinuous boundary by Torrabolls farmhouse and Cnoc-an-t-Sleibh, till it is terminated by a fault which passes through the Finlaggan valley and extends north-east to the sea at Bonahaven. The rock is exactly similar to that already described in the neighbourhood of Portaskaig. In the north of the area the quartzite (Group 2) appears in its natural position above the conglomerate, and the sudden variations in the dip of the strata show that both rocks have been sharply folded, the latter also being much cleaved. The fault which for a short distance forms the southern boundary of the area has a downthrow to the east, bringing the Portaskaig conglomerate at the base of the quartzite against the fucoid-like beds, which occur several hundred feet higher up in the series. At a distance of three hundred and fifty yards from the sea, the conglomerate leaves the line of fault and forms a small cliff feature at the edge of the arable land, which is chiefly occupied by the Islay limestone. The intercalated bands of rusty-weathering dolomite are present here in the conglomerate as in other localities, so that at this point, within a triangular-shaped area of very small dimensions, calcareous rocks at three distinct horizons—the Islay limestone, the dolomite in the conglomerate, and the creamy-white dolomite peculiar to the fucoid beds—can be observed within a short distance of one another. Westwards from Torrabolls farm, the conglomerate is seen resting in turn upon different members of the limestone-phyllite series until it is cut off to the north of Balulve by the Finlaggan fault.

Numerous small outliers of the Portaskaig conglomerate are scattered over the area between Torrabolls, Balulve, and Kiels, most of which contain pebbles of oolitic limestone derived from the Islay limestone.

The sections seen in the area to the north of Bridgend, between Loch Skerrols and Finlaggan Loch, clearly show the relations of the Portaskaig conglomerate to the underlying Islay limestone and phyllite. From the effects of surface denudation and consequent partial erosion of the overlying formation, the higher ground is now occupied by the conglomerate, and the sides and lower portions of the valleys by the Islay limestone and phyllite series. There are, however, exceptions where the Portaskaig conglomerate is found in small outliers on the low ground. The character of the conglomerate varies considerably within this area. At Octavulin and Skerrols, where the rock is folded with the Islay limestone, the matrix of the conglomerate is composed of red sandy shales and flags with numerous lenticular pebbles of limestone; while in the neighbourhood of Eorrabus the matrix is a limestone, charged with numerous limestone pebbles. As the observer follows the sinuous outcrop of the conglomerate northwards by Duisker to the foot of Carn nan Gillean, and southwards on either side of the inlier of Islay limestone on which the farm of Scarrabus is situated, the nature of the rock and its relations to the underlying strata can be frequently examined. The conglomerate shows the usual red shaly matrix with occasional bands of sandy flagstone, quartzite, and dolomite; and is freely charged with pebbles of limestone, quartzite, vein-quartz, granite, and gneiss.

On the western side of the Ballachlavin valley, where, near its head, it is crossed by a dolerite dyke, the Portaskaig conglomerate is seen resting upon a smaller inlier of the dark phyllites which underlie the Islay limestone; while near the outcrop of the same dyke on the other side of the valley, it rests upon the limestone. A similar transgression of the conglomerate from one member to the other of the limestone and phyllite group can be observed at several localities as the outcrop is traced round the southern extremity of Cnoc an Tighe and north-eastwards past Seanghart to the shore of Loch Finlaggan.

The boundary drawn between the quartzite and the Portaskaig conglomerate for some distance north of Loch Finlaggan is a somewhat hypothetical one, the ground being largely occupied by superficial deposits. To the north of Torrain Dubha, where the ground rises from beneath the peaty covering, the two rocks are seen in close continuity, and though the actual junction is not visible it is evident that the quartzite rests upon the conglomerate. In the Strath Luachrach burn, a hard, white, evenly-bedded quartzite, with numerous small pebbles of white quartz, is seen dipping steadily off the conglomerate in a north-north-east direction at 10° to 20°.

Further to the west the boundary between the two rocks becomes less sharply defined, and shows a more gradual passage from the conglomerate into the quartzite, the former becoming more quartzose, the latter more sandy and brown in colour.

The next area to be described is of a very small extent. It lies in the immediate neighbourhood of Upper Gluich, a ruined croft three-quarters of a mile south-east of Daill and two miles east by south of Bridgend (see Sheet 27). Here, infolded with the underlying phyllites and limestones, are several small outliers of a quartzose rock with a somewhat calcareous appearance on weathered surfaces, which may probably represent the Portaskaig conglomerate.

Tallant Outlier.—At a point on the north-west side of the fault, four hundred yards from Tallant farmhouse, south-east of Bowmore (Sheet 19), calcareous sandy beds are seen in conjunction with the Islay limestone. At the base of these sandy beds and resting on the limestone, is a thin layer of the peculiar limestone breccia of the Portaskaig conglomerate. In the field north of the road, within two hundred yards of the last exposure, the conglomerate with its characteristic features is well developed, and is seen at intervals over an area half a mile long by two hundred and twenty yards broad. At the old house standing in the field a sheared lenticular band of quartzite appears, which is probably one of the quartzite bands commonly found in the conglomerate, as immediately north-west of the old house conglomerate again crops out and seems to pass into the quartzite, which is intensely sheared, and is separated from the Torridon sandstone on the north by what is believed to be the Skerrols thrust-plane. It is remarkable that even in this disturbed area the Portaskaig conglomerate retains its usual position between the limestone and quartzite.

STRUCTURAL RELATIONS OF THE MEMBERS OF THE NORTHERN SERIES.

The order of succession of the groups represented in the Northern Series is clearly displayed on the shore section between Portaskaig and Bonahaven Bay, where the sequence is not much disturbed save by normal faults.

Beginning at Portaskaig and proceeding northwards the observer traverses the conglomerate at the base of the series with thin intercalations of quartzite and sandy dolomite, the general inclination of the beds being towards the north-west. At Caol Ila Distillery the conglomerate is followed in normal sequence by the quartzites (Group 2), which there dip in a similar direction at an angle of 28°. The local boulder bed at the top of the latter sub-division is not represented in this section, the quartzites being immediately overlaid by the phyllites, ripple-marked and worm-tracked shales, and flags (Group 3). About a quarter of a mile north of the distillery the band of quartzite with ripple-marks and annelid pipes (Group 4 in section) appears, overlaid by the fucoidal shales and flags (Group 5) which are admirably seen on the shore north and south of Na Feamindean. Not far to the north of the latter headland the fucoidal shales and dolomite are truncated by a normal fault with a downthrow to the east (see section) whereby the whole sequence of the Northern Series is repeated between Ardnahoe and Bonahaven Bay.

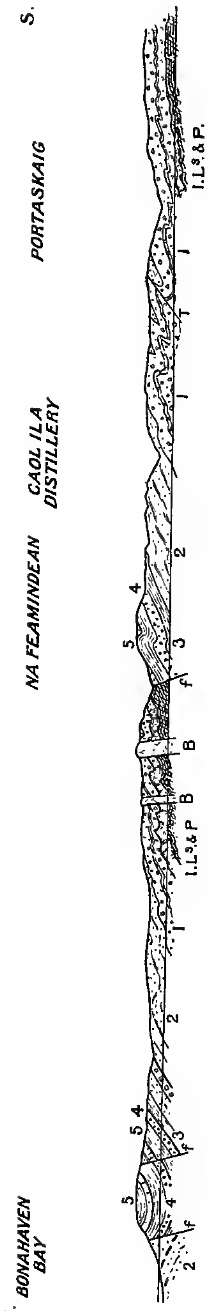


Fig. 4.—Section from Portaskaig to Bonahaven Bay.

I. Ls. and P. = Islay limestone and phyllites. 1. Portaskaig conglomerate. 2. Quartzites. 3. Ripple-marked shales and flags with dolomitic bands. 4. Quartzite with annelid pipes. 5. Fucoidal shales with bands of dolomite.

In this northern area the basal conglomerate presents its normal features and has a similar dip towards the north-west. On the shore section north-east of Ardnahoe Loch a small fault or line of crush appears near the junction of the conglomerate and overlying quartzite (Groups 1 and 2), which is not shown on the accompanying section as it probably does not seriously affect the relations of the rocks. The local boulder bed occurs near the top of the quartzites, being visible on the shore about one-third of a mile south of Rudh a' Mhail, where it contains pebbles of granite, quartzite, and shales. The ripple-marked and piped quartzite (Group 4) occupies its proper position, and on the headland south-east of Bonahaven Bay there is a fine development of the dolomitic bands associated with the members of the highest sub-division (Group 5). At the northern limit of the section the sequence is again interrupted by a normal fault with a downthrow to the east, on the further side of which the quartzites (Group 2) are found.

Throughout the hilly region between Bridgend and Loch Finlaggan on the south, and Rudha Bholsa and Rudh a' Mhail on the northern shore, the various groups of the Northern Series are, on the whole, remarkably persistent, being repeated by a series of prominent folds and parallel faults trending north-north-east and south-south-west.

By far the most conspicuous example of the system of folding is the well-marked compound anticline whose axis extends from Cnoc-t-an Samhlaidh, about two miles west of Bonahaven Bay, to the farm of Ballachlavin near Finlaggan Loch, a distance of four miles. The various sub-divisions can be traced on both limbs of this arch and are found to retain their respective positions as in the coast sections between Portaskaig and Bonahaven. Towards the south limit of the anticline the basal conglomerate (Group 1) rests unconformably on the Islay limestone and phyllites in the neighbourhood of Ballachlavin and on the west shore of Loch Finlaggan. It is succeeded in a north-easterly direction by the quartzite (Group 2), and following the same course the higher beds of this formation are reached, the upper band of conglomerate appearing from under the peat at Cro Earraich. A short distance from this point, at the edge of the peat moss, the quartzite is found to pass up into the strata of Group 3. The actual junction or line of passage between these two groups is much obscured by peat and drift, but the strata are laid bare at sufficient intervals to make it possible to draw a fairly accurate boundary between them. This boundary follows the course of the burn along the east and north sides of the Sliabh Bhirgeadain peat moss for a distance of a mile, when it bends sharply to the north and sweeps round Cnoc-an-t-Samhlaidh to Loch Guirbheinn, where a north and south fault, of no great structural importance, throws it back to the north for a distance of three-quarters of a mile, causing the strata to be repeated along the summit ridge and south-west face of Guirbheinn. Next in order comes the quartzite band with annelids (Group 4), visible in the stream due north of Cro Earraich and traceable from this point northwards round Cnoc-an-t-Samhlaidh and south to Loch Guirbheinn, the outcrop keeping nearly parallel to that of the main quartzite of Group 2. It can be followed also along the summit ridge of Guirbheinn, where excellent sections show its relations to Groups 3 and 5. The rock is white in colour, shows marked false-bedding, and contains numerous small pipes *(Scolithus linearis.)* This persistent band is overlaid by the fucoidal shales and white cream-coloured dolomites (Group 5) which are traceable round the north and north-east sides of the anticline.

On referring to Sheet 27 it will be seen that along the west limb of this great compound anticline the three highest sub-divisions (Groups 3, 4, and 5) have been followed in normal sequence from Loch Raonabuilg in a south-south-west direction to Carn nan Gillean, a distance of three and a half miles, where they form a narrow belt about a quarter of a mile across. Along their western margin these higher groups are truncated by a strike fault running north-north-east and south-south-west along Glen Airidh (see Sheet 27), whereby the quartzite of Group 2 is brought up against the members of Group 5 on the east. Westwards the various Groups 2, 3, 4, and 5 are again repeated, preserving their relative positions in ascending order, the members of the higher sub-divisions forming a narrow belt over six miles in length, as laid down on the map. The sequence is again interrupted by a second strike fault parallel to the one in Glen Airidh, traceable from Loch Cam in the south to Sgarbh Dubh in the north, by which the quartzites (Group 2) are brought up and spread over a wide area westwards to the Skerrols thrust-plane. S. B. W.

A continuous section of these quartzites is exposed along the northern shore of the island between Gortantaoid Point and Rudha Bholsa. The rocks are thrown into a succession of isoclinal folds whose limbs dip north-west at angles of 40°–50°. One of these compound overfolds is graphically shown in the accompanying sketch of one of the caves at the head of the little bay opposite Biod nan Sgarbh, where the core of the fold has been hollowed out by the action of the sea.

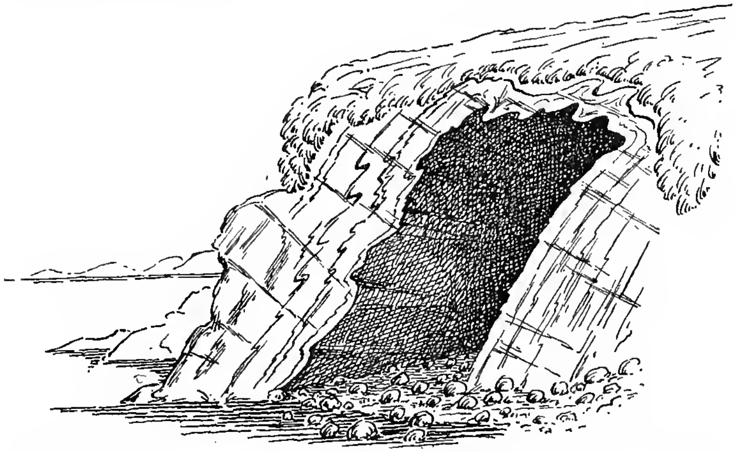


Fig. 5.—Folded quartzite near Biod nan Sgarbh, four miles north-east of Loch Gruinart.

Proceeding eastwards along the coast between Rudha Bholsa and Rudh a' Mhail we find confirmatory evidence of the order of succession of the members of the Northern Series and of their repetition by folds and faults. In places the beds are cleaved and shattered, but on the whole they are comparatively unaltered, and the distinctive features of the three higher sub-divisions are easily recognised.

A glance at the map (Sheet 27) shows that the quartzites (Group 2) forming the promontory of Rudha Bholsa are cut off on the east side by a fault with a downthrow to the east, which brings in the overlying Groups 3, 4, and 5. East of this dislocation these higher sub-divisions occupy the coast-line for half a mile, and are arranged in compound synclinal folds along axes trending north and south. As the observer proceeds eastwards from the fault, he first encounters pebbly quartzites which probably represent the boulder bed at the top of Group 2, followed by the worm-tracked shales and dolomitic bands of Group 3 and the piped quartzite (Group 4), till at Port an Sruthain and along the shore for a quarter of a mile beyond, he finds a repetition of the fucoidal shales and cream-coloured dolomites of Group 5. Eastwards these higher zones appear in descending order and eventually the quartzites with the boulder bed near the top, containing granite pebbles, come to the surface near Port a' Chotain and occupy the shore for a considerable distance. Eastwards, between the quartzites of Port a' Chotain and the sandy bay named Bagh an da' Dhornis, for the distance of a mile, there is a splendid development of the members of Group 5, the beds being constantly repeated by shallow folds for the most part normal though occasionally isoclinal in character. The greenish-grey and rusty-weathering dolomitic shales with partings of silky shale and thin bands of quartzite are there associated with numerous beds of cream-coloured dolomite. In their lithological character, their mode of arrangement, and their fossil contents, they greatly resemble the fucoid shales of the North-west Highlands which yield the *Olenellus* fauna. On the northern shore of Islay a careful search has been made by Mr. Macconochie for traces of *Olenellus*, but hitherto without success.

The nature of the junction between the fucoidal shales of Bagh an da' Dhornis and the quartzites of the promontory of Rudh a' Mhail is very obscure, but it is probably a faulted one. On the east side of the bay a small skerry of fucoid shales, dipping south-east, appears near the base of the cliff of quartzite, which is surrounded by beach material, thus concealing the line of junction.

From Rudh a' Mhail southwards to Bonahaven Bay there is a belt of quartzite (Group 2) which, as shown on the map, is bounded along its western margin by fucoidal shales, flags, and bands of dolomite belonging mainly to Group 5 and partly to Group 3. Only at one point along this line are the quartzites seen in contact with the higher beds, viz., in the Margadale river, which flows into Bonahaven Bay. For some distance below the junction the quartzites are inverted, being inclined to the south-east at varying angles. At the contact they are underlaid by shales and dolomitic bands which dip in a similar direction, and further up stream a band of dolomite is repeated several times with a persistent inclination to the south-east or east-south-east. From the available evidence it is probable that, notwithstanding the inversion of the strata and the absence of the boulder bed near the top of Group 2, there is here a natural passage from the quartzite into the fucoidal shales and dolomitic bands of Group 3. B. N. P.

The quartzite of the northern area is separated from the Torridonian rocks in the west by the line of discordance referred to as the Loch Skerrols thrust-plane. The course of this line between Loch Gruinart and Laggan Bay has already been indicated in Chapter II. The first point where the two formations can be seen in conjunction is on the shore opposite Bun-an-uillt farmhouse, where a clear section exhibits the effects of the over-thrusting of the quartzite upon the Torridonian rocks. At this point the quartzite is drawn out in a direction running west 30° north and east 30° south and is also minutely folded in a direction almost at right angles to the above, the movement having been evidently from east-south-east. It is also filled with lenticles and streaks of quartz, elongated in the direction of movement and sometimes granulitised; the general dip of the planes of schistosity is to east-south-east. A few yards south of a small dolerite dyke that crosses the beach, the outcrop of the thrust-plane is seen trending north-east by north, and dipping to the south-east at 20°. Above the thrust-plane the quartzite is intensely sheared and foliated, the planes of foliation being obliquely truncated by the thrust-plane. The quartzite is underlain by an inch or so of finely ground-down material which is now passing into a clay. The rock immediately below the thrust-plane on either side of the little dyke mentioned above is made up of quartzose material which is even more intensely deformed than the quartzite above the plane of movement. These rocks resemble sheared Torridonian grits, they decompose with a rusty surface, and are more micaceous than the quartzite. They also contain numerous lenticles and veins of quartzo-felspathic material introduced along the foliation planes. In some cases these are stretched and granulitised, proving that the movement must have been intermittent. The beach deposits conceal the rock for some distance northwards from this point, and where the quartzite reappears at the mouth of the Bun-an-uillt burn it is much less deformed, but greatly shattered and disturbed by a succession of small faults trending north 30° east. Both in the Bun-an-uillt burn a mile above the farm of that name, and in Gleann Mor, two miles to the south-south-east, the Torridonian grits and the quartzite can be seen within a short distance of one another, but in neither locality is the evidence as to their structural relations conclusive.

For a mile northwards from Loch Skerrols the quartzite has undergone extreme deformation, and although the exact position of the thrust-plane cannot be determined, it is easy to follow its general trend by the amount of movement which has taken place along the line of discordance. The direction of stretching lies between north 10° west and north-west, and the general dip of the planes of schistosity is to the south-east at 30°.

A traverse across the strike of the beds from the shore of Loch Cam to the western boundary of the quartzite will convey to the observer some idea of the enormous dynamical forces which have been brought to bear upon the rocks along this line of thrust.

Slight but gradually increasing signs of movement are first seen in the rock; a little further west patches of sheared material make their appearance, surrounded by unsheared quartzite which has so far resisted the movement. Still further to the west more and more of the mass has been drawn into the mill, until at the margin, and particularly on the shores of Loch Skerrols, the quartzite has been rolled and drawn out until the rock resembles a mass of glass in a semi-molten condition.

An important outlier of quartzite occurs at Mulindry, three miles east of Bowmore (Sheet 19) and stretches south-west from Cnoc Donn for a distance of more than a mile. At the north-west extremity of the area the quartzite seems to pass insensibly into impure calcareous grit in bands alternating with buff-coloured dolomite. The quartzite of Cnoc Donn is massive and pebbly, many of the pebbles being as large as a pea and consisting chiefly of blue quartz. The dip is consistently south-east, at a high angle, and the strata are evidently disposed in a series of isoclinal folds. From the west side of Cnoc Donn to a little beyond Mulindry Bridge there is an outcrop of dolomitic limestone. It is evident that the same system of plication that obtains in the quartzite south-east of the band of limestone also occurs to the north-west of the same band, the calcareous gritty bands having been spread out by repeated folds. The evidence here brought forward leads to the belief that there is a gradual passage up from the quartzose rock through the dolomitic limestone and sandy and pebbly calcareous bands into a less pebbly quartzite. This passage from the conglomerate to the quartzite has been proved to exist in many other localities.

The same rusty calcareous quartzites are seen across the river at Mulindry, and on Cnoc Cro a' Mhail, a little further south, another outlier of quartzite occurs, dipping south-east. It is a white, massive, thick-bedded gritty or pebbly rock, containing many blue quartz pebbles, and is traversed by many quartz reefs. The relation of this quartzite to the more calcareous beds to the north-west is concealed by drift; but it follows the strike of the Cnoc Donn and Mulindry ridge, and probably represents the south-western extension of the same system of folds.

The occurrence of a conglomerate, referred to the Portaskaig conglomerate, at the base of the quartzite in the Tallant outlier near Bowmore has already been described on p. 48. The quartzite which succeeds the conglomerate in the northern part of the outlier is intensely sheared, and closely resembles the rock seen at Loch Skerrols. The direction of the stretching is west 30° north, and the dip of foliation east 30° south at 70°. The amount of deformation in the quartzite at this point suggests the strong probability that the outcrop of the Loch Skerrols thrust-plane is close at hand, a supposition which is strengthened by the occurrence, only 45 yards to the north, of the Bowmore grits in a very slightly sheared condition. About fifty or sixty yards further north-west another quarry exposes the same grits and arkoses with their characteristic pebbles of fresh felspar and colour-banding. S. B. W.

CHAPTER VIII.

LOWER OLD RED SANDSTONE.

Rocks which have been provisionally assigned to this division of the Old Red Sandstone, owing to their similarity to those of the volcanic platform of Lorne, occur upon Glas Eilean, a small island off the Jura shore of the Sound of Islay three miles south of Portaskaig. In the parts of the island not covered by beach deposits, a succession of basic lavas are seen dipping towards the west-south-west, at angles of 30°–40°. The upper surface of the lavas is very slaggy, and in places they are covered by calcareous red sandstones which fill up their cracks and irregularities. The main type of rock contains phenocrysts of augite, olivine, and (rarely) felspar, in a microlitic groundmass, and is, therefore, an olivine basalt. The island was visited by Sir Archibald Geikie during the summer of 1897, who, in his Report of Progress of the Geological Survey of that year, gives the following description:—"The rocks appear to consist chiefly of purplish-grey amygdaloidal andesites and decayed basalts. They show abundantly a true slaggy structure, their vesicles being commonly filled with calcite. A conspicuous feature among them links them with the volcanic series of Lorne and of the Lower Old Red Sandstone of Central Scotland, viz., the abundance of veinings and irregular layers and nests of pale-red fine-grained sandstone. Some parts of the lava have been entirely broken up into masses of slag, between which the sandy sediment has accumulated, precisely as may be seen on the coast sections at the Red Head of Forfarshire, Turnberry Point in Ayrshire, and many sections round Oban. The lavas of this island occur in successive sheets, dipping towards the Sound at perhaps 30° to 40°. They are separated by grassy hollows, some of which may conceal bands of tuff or ordinary sedimentary material. There can hardly be any doubt that Glas Eilean is a fragment of a volcanic series of the age of the Lower Old Red Sandstone. It lies nearly forty miles to the north of the rocks of that period in Arran and Cantyre, and fifty miles south from the volcanic masses of Oban. It not improbably marks the site of a distinct volcanic area about half way between that of Lorne and the Clyde." B. N. P.

CHAPTER IX.

TRIAS.

The rocks which are considered to belong to this formation occur as a breccia filling in a "swallow hole" or underground cavern in the Islay limestone, formed at a time when the relative position of sea and land was very different from that now extant. The breccia now forms part of a sea-stack which is still attached to the mainland by the narrow neck that forms the northern horn of the little sea-cove Port nan Gallan, already referred to as situated one mile to the east of the Mull of Oa, the most south-westerly point of Islay.

The breccia consists of a tumultuous aggregate of blocks of quartzite, limestone, and schist, set in a matrix of bright red sandstone with well-rounded grains of quartz. The matrix is for the most part cemented by calcareous material, but it is sometimes quite friable and bears a close resemblance to that of the basement beds of the Triassic outliers of Arran, Ballantrae, and Loch Ryan; and also to those found far to the north on the Ross-shire shores of the Minch.

The breccia forms a more or less vertical sheet running north and south, plastered on to the landward side of the stack, which is here over 100 feet in height and chiefly composed of the phyllites and limestone of the Southern Series. On the north side of the stack the breccia extends westwards through a nearly horizontal tunnel overhung by the limestone and schist. The northern side of this tunnel has been cut away and the bottom is hidden by the beach. In this part of the exposure the quartzite blocks are very large and angular.

The mode of occurrence of this formation leaves no doubt that it accumulated in an underground cavern at a considerable depth from the surface. The material must have fallen down a more or less vertical fissure and been borne by water along a nearly horizontal tunnel, the sides of which have been removed by the sea during the isolation of the stack from the adjacent cliffs of the Bruthach Mòr. Not only is the matrix of the breccia bright red, but the limestone and schist of the stack and the adjoining mainland are stained a deep-red colour, which has given rise to its combined Scandinavian and Gaelic name of Cleit Ruadh, or Red Cliff.

This isolated underground outlier must have been formed at a time when a red sandstone was being deposited on the then existing surface, and suggests the idea that a part at least of Islay may have been covered at no very distant date by such a formation. The red staining of the joint-planes in the quartzite of the Mull of Oa promontory, and the blood-red colour of the boulder clay over a great part of the island, gives a certain amount of support to such an hypothesis. This red formation was in all probability the northern extension of the Trias of Arran and the north-east of Ireland.

B. N. P.

CHAPTER X.

EPIDIORITE AND HORNBLENDE-SCHIST.

(*Later than the Lewisian gneisses of the Rhinns of Islay.*)

These rocks are green in colour and frequently effervesce freely with acid. In texture they vary from coarse to fine, and in habit from massive to schistose. Some are porphyritic with large idiomorphic crystals or crystalline patches of felspar, generally too much altered for precise determination. The coarse-grained non-porphyritic rocks sometimes show a granitic structure, at other times they are characterised by large patches of ophitic hornblende, which give a pseudo-porphyritic aspect to the specimen. The ferro-magnesian constituents are now hornblende, generally fibrous, and chlorite; but it is probable that both these minerals have resulted in many cases from the alteration of an original augitic constituent.

The epidiorite intrusions are found in greatest abundance along the south-east coast between Rudha nan Leacan, the most southern point of the island, and Carraig Mhor at the southern entrance to the Sound of Islay. Along this belt the epidiorites appear in the form of numerous sills in the softer members of the series—the phyllites, mica-schists, and Laphroaig grits—and have not invaded the main quartzite. Owing to the absence of drift the rock is constantly exposed, particularly in the area between Port Ellen, Claggain Bay, and Ardmore. The epidiorites form serrated ridges, giving rise to fine craggy features. These ridges are arranged in a south-west and north-east direction, corresponding to that of the axes of the folds of the sedimentary rocks. It is, indeed, evident that these sills have shared in the plication of the district, and that their frequent occurrence is in large measure due to folding. At Rudha nan Leacan, the south-west extremity of the Oa promontory, a massive sill of rather coarse-grained green epidiorite, more than one hundred yards broad, extends along the coast-line for a distance of half a mile. The igneous rock contains caught-up fragments of the grey silvery slates and shales into which it is intruded, and which are bleached and indurated along the line of contact.

It is not till Port Ellen is reached that these igneous rocks are again met with, but here, within the zone of phyllites, the epidiorite sills are very numerous. Two hundred yards north of the White Hart Inn a band of thoroughly foliated hornblende-schist crops out on the hillside above the raised beach. At Rudha Glas, near Port Ellen School, a band of calcareous chlorite schist has been traced inland to the farm of Torradal, a distance of rather over a mile, and near the Free Church numerous thin bands of a similar rock, sheared and repeated by folding, occur. East of the Free Church a quarry has been opened in a sill of dark-green very fine-grained chlorite schist, but is now almost worked out. The stone is wrought into shaped slabs and ornamental chimney pieces, and it is probable that many of the ancient sculptured Iona crosses found in the island are of a similar rock. Passing south to the promontory known as The Ard, where a continuous rock section is exposed, the epidiorites and hornblende-schists are constantly seen in contact with indurated grey phyllites and grit bands. Fifty yards south of Rudha a' Chuinnlein, another ridge, on which stand the ruins of an old castle, is formed by a sill of massive porphyritic epidiorite, remarkable for its toughness. The matrix of the rock is greenish and contains large crystals of a pinkish felspar, sometimes over an inch in length. Another similar sill a short distance further to the south is seen to cut obliquely across the bedding of the indurated sedimentary rocks. The skerries of Sgeir Fhada, Eilean nan Caorach, and Sgeir Phlocach are also formed of epidiorite, and on the adjoining island of Texa there are two thick sills of this rock.

The inland prolongations of the sills exposed on the mainland shore section just described are well seen in the ground between the bay at Sron Dubh and Torradal, where they give rise to no less than nine conspicuous rock ridges. A sill of massive porphyritic epidiorite with finer-grained margins forms a well-marked ridge between the head of Loch Laphroaig and Ardbeg Distillery, a distance of nearly two miles. At Laphroaig Distillery it is seen in contact with the Laphroaig quartz-schist. The promontory to the south-east of Loch Laphroaig is formed of two massive sills of epidiorite separated by a lenticular area of indurated and altered slates pierced by two smaller parallel sills, the whole being probably a repetition by folding of the same sheet of igneous material. A good section is seen at the western entrance to Lagavulin Bay, where grey shales are exposed on the shore, overlaid by a fine-grained chlorite schist. This is followed by three feet of baked shales, apparently thinning out to the west, and overlying these again is a massive epidiorite, schistose at its junction with the shales, and containing a considerable quantity of iron pyrites. It is cut at this point by a narrow basalt dyke. In the area stretching north and west of Ardbeg Distillery, the chief features of the country are the innumerable parallel ridges and ribs of rock due to the outcrop of rapidly folded sills of epidiorite and hornblende-schist. The folding to which this repetition is due is well seen at the point four hundred yards due east of the distillery, where one of these sills is sharply bent, the fold pitching out seawards and enclosing a belt of Laphroaig quartz-schist and grey phyllites. The eastern limb of this fold forms the coast-line for about six hundred yards, when it runs inland in a north-easterly direction and can be traced as far as Ardilistry. The western limb runs in a direction parallel to the eastern area for a distance of three-quarters of a mile, when it evidently bends round to join the sill of similar rock on Druim Dubh. The rapid change in character often found in these sills is well marked at the point three hundred yards to the south of Ardbeg Distillery. The shearing force to which the sill has been subjected at this point has resulted in the production of fine-grained chlorite schist.

Ard Imersay, the promontory south of Kildalton House, is also chiefly occupied by sills of epidiorite, repeated by folding. Torr na Carraige, the point east of Kildalton House, is formed of epidiorite with granitic structure and segregations of albite on one surface ((B) $\frac{332}{\text{S.E.}}$). The numerous skerries off this point are also composed of epidiorite, and represent the continuation of the different sills on the mainland.

In the region further to the north and north-west these epidiorite intrusions are so extremely numerous that it has not been found possible to represent more than a certain proportion of them upon the one-inch scale map. In the following descriptions only those presenting some special points of interest will be referred to. The Ardilistry river is crossed at a point one-third of a mile west of Ardilistry shepherd's house by a narrow ridge of fine-grained chlorite rock, slightly schistose and probably a modified epidiorite. At the east side of Loch nan Clach a massive sill of highly porphyritic epidiorite trends north-east and south-west. The large phenocrysts of felspar (now much altered) often present rounded outlines. At a point a quarter of a mile west of Loch Tallant the epidiorite contains small scales of brown mica. In the neighbourhood of Cnoc a' Chorrbhealaich these sills seem to have been considerably deformed, and while in some of the outcrops the rock is still in the form of a massive porphyritic epidiorite, in others it has been sheared into a calcareous chloritic rock, showing a greater or less degree of schistosity. A good example of this differential metamorphism is seen to the west of Loch Carn a' Mhaoil, where the thick sills which form the ridge of An Dun and extend northwards to Dun Fhinn are composed of porphyritic epidiorite, while the thinner intrusions on either side are completely sheared into chloritic schist. It is, however, probable that these two types of rock represent two sets of intrusions varying slightly in original composition.

This group of massive epidiorite sills continues in a north-easterly direction across the Kintour river and over Cnoc Mor na Claigin and Maol Ardtalla to the sea at Carraig Mhor. Their central portions are coarse and highly porphyritic, their margins generally finer-grained and foliated. Another group of epidiorite sills similar in character to those described above extends south-west from Trudernish Point and Rudh a' Mullaich Bhain to Rudha nan Mairtuinn, opposite Kildalton House. To the south of the Kintour river they are often seen in contact with the quartzose schists and phyllites, and in Aros Bay with highly calcareous shale and thin limestones, the sedimentary rocks showing the usual induration. Finer-grained epidiorites, well sheared along their margins, and thinner sills of chloritic schistose rock are intruded into the hard gritty quartzites of Ardmore Point. The islands and numerous skerries south of Ardmore are formed of quartzite with sills of sheared epidiorite and chlorite schist, the brilliant whiteness of the quartzite contrasting well with the dark-green of the igneous rock. The island of Outram is entirely composed of greenish epidiorite, highly sheared in places, with patches of fibrous hornblende and wedge-shaped inclusions of quartzite; and similar rocks form nearly the whole of Eilean Bhride.

Although nowhere else in the island is there the same great development of epidiorite sills as in the south-eastern belt just described, there are several localities outside that region where they occur. Within the central phyllite and limestone belt on the north side of the main quartzite, sills of epidiorite are found on the Oa; between the Torran and Glenegedale rivers south-south-east of Bowmore; on the western and northern slopes of Beinn Bhan; and north and south of Daill near Bridgend.

In the Oa promontory a few small sills of greenish-mottled epidiorite occur near Upper Killeyan and at the edge of the cliff at Rudha Dubh Allt na Muice in contact and folded with the limestone and phyllite. There are other small intrusions around Tackmal and Glendhu.

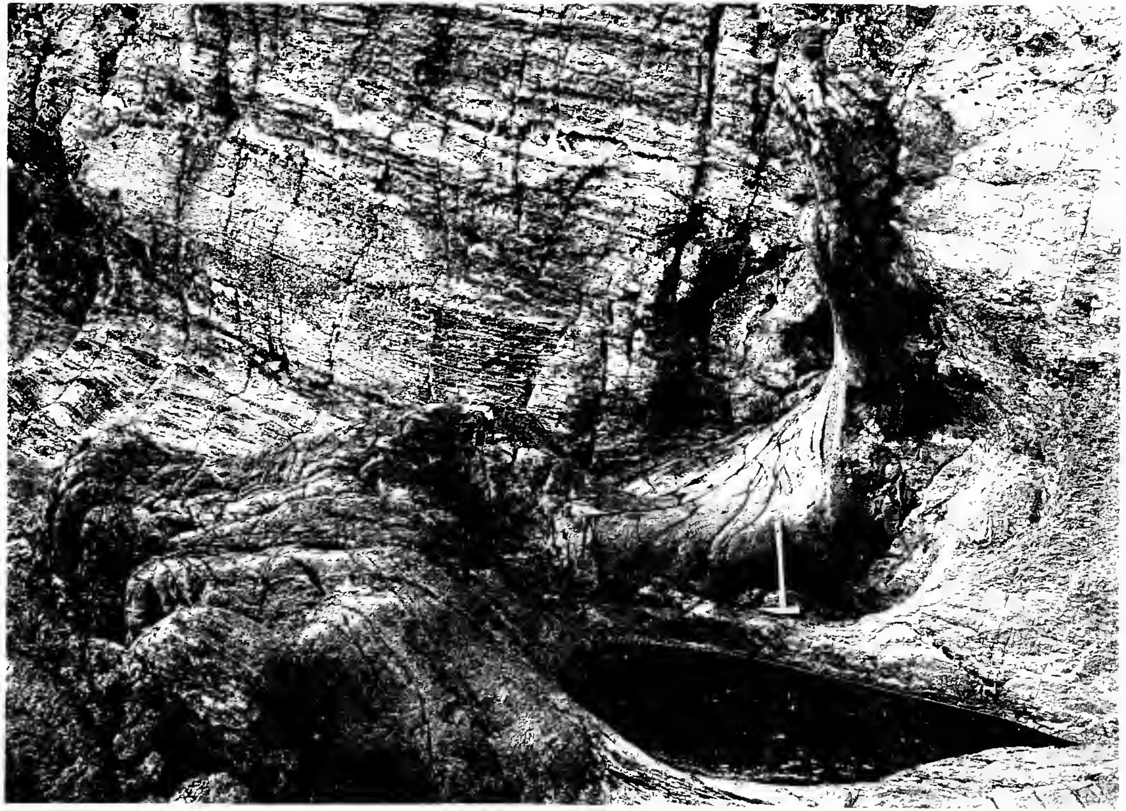
The broad massive sill which extends over Cnoc Grianail from the roadside five miles south by east of Bowmore, and the smaller exposures that appear through the superficial deposits eastwards across Druim Fada towards the Torra river, are all of the same medium-grained greenish-mottled epidiorite. A large area of a somewhat coarse-grained rock, sheared along its western margin where it crosses the Abhuinn Bhogie, appears on Cnoc na tri-dail, and the same group of sills can be traced by small isolated outcrops through the drift to the Kilennan river, where the epidiorite is seen at two several points half a mile and three-quarters of a mile above the ford in the bed of the stream. Still further to the east towards Loch Allallaidh and the head of Allt nan Gamhna, masses of epidiorite of the ordinary type occur both within the Islay limestone and in contact with the phyllites.

A few small sills of epidiorite are found north of the Laggan river in the neighbourhood of the farms of Nereby and Daill, and to the east of Cnoc Donn. In each case they are intimately folded with the limestone and phyllites of the central belt. Intrusions of epidiorite are also found within the main quartzite outcrop of the Southern Series, on either side of the summit cairn on Beinn Bhan, between that hill and Beinn Uraraidh, and immediately to the south of Loch Allallaidh. They occur in the form of bands and lenticular masses, and appear to be intruded both along and across the planes of bedding of the quartzite. The rock is of the usual type, a hard, mottled, green, medium-grained epidiorite, sometimes slightly porphyritic in structure.

The Torridonian grits in the area between Bowmore and Bridgend are pierced by several small intrusions of epidiorite. Lenticular sills of fine-grained bluish-green rock, thoroughly schistose in structure, occur in the hill of Carnbuie, 220 yards north of Gartmain Farm; and on the Monument Hill immediately south of Bridgend.

A small sill of epidiorite is also found in a quarry in the Torridonian grits opposite the south lodge-gate of Islay House, on the Bowmore road.

PLATE VI.



Foliated and Contorted Dyke of Lamprophyre in Phyllites (Torridonian ?),
Shore, ½ mile North of Portnahaven, Islay.

FELSITE.

A small dyke of felsite occurs in the cliff near Campa, south of Saligo Bay on the west coast of the Rhinns. It is a compact, close-grained, light-coloured rock, and weathering very white, contrasts with the dark Torridonian slates into which it has been intruded.

LAMPROPHYRES.

A typical minette, composed of numerous conspicuous plates of biotite set in a fine-grained pinkish matrix, occurs as a dyke to the north of Kildalton, on the west bank of the stream between Loch Carn a' Mhaoil and Loch Tallant. It follows the general course of the epidiorite sills, but, unlike them, has not been affected by the movements that have produced the schistosity in the surrounding rocks.

Dykes of mica-trap also occur on the west side of the island in the sedimentary rocks which have been somewhat doubtfully referred to the Torridonian. Some of these, as, for example, those occurring in the Kilchiaran slate quarry, have been affected by movement, and pass into a special type of chlorite-schist consisting mainly of chlorite, alkali-felspar, and carbonates. The least altered rock from this quarry consists of biotite and alkali-felspar with carbonates, epidote, and pyrite as accessories.

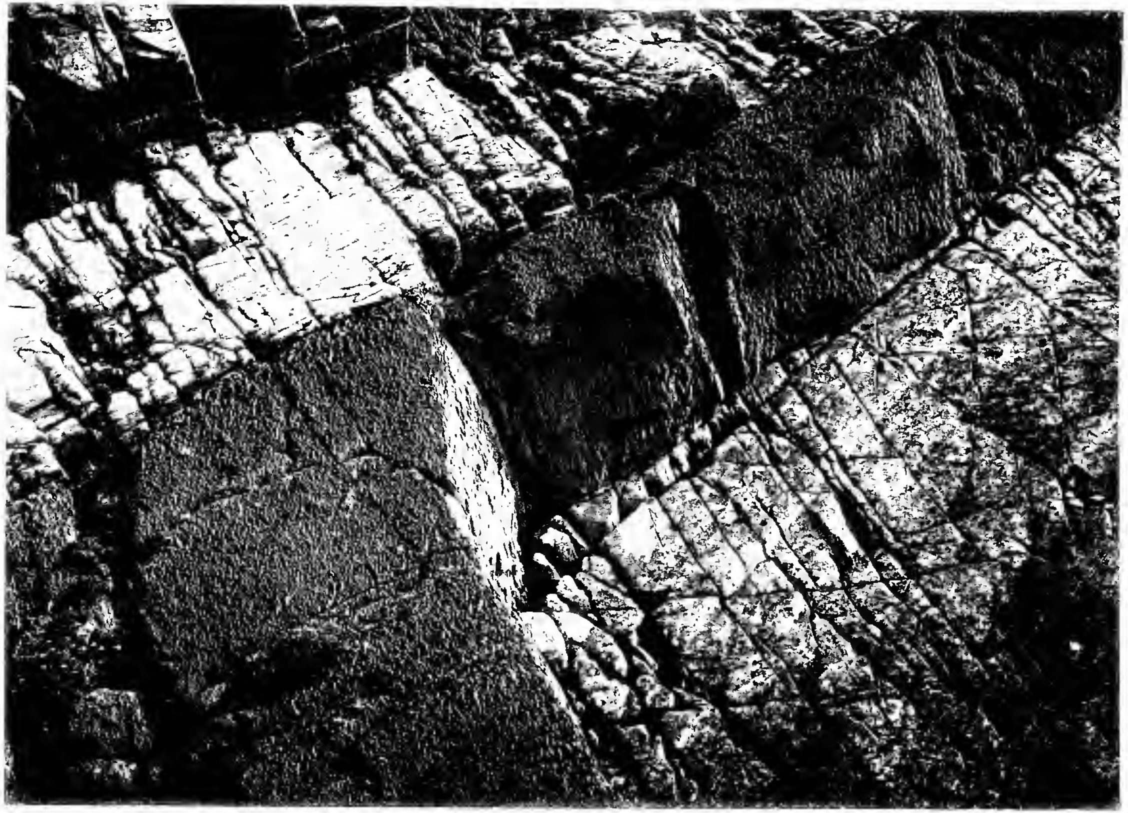
The dykes classed as diorite on the map and occurring in the same district, have also decided affinities with the lamprophyre group and may be referred to in this connection. A specimen from Saligo Bay is a coarse-grained rock composed of biotite of the mica-trap type, green pseudomorphs after hornblende or augite and alkali-felspars, with apatite, sphene, and iron-ores as primary, and carbonates, chlorite, and epidote as secondary accessories. A similar rock occurs on the north shore of Machir Bay, where it is associated with a finer-grained variety containing long prisms of brown hornblende (vogesite).

Other rocks of the lamprophyre group are confined to the Rhinns of Islay, where they appear in several localities.

On the shore opposite to the Free Church Manse north of the village of Port Charlotte, several decomposed lamprophyre dykes cut the sediments at their junction with the gneiss. Also on the west coast, about a mile north of the village of Portnahaven, there are several small dykes and sills belonging to this group. One of these, seen on the face of the cliff that bounds Port Mias Sgeire on the north, is intensely twisted and contorted, while a subsequent cleavage, trending north-east and south-west, cuts the contorted foliation planes (Plate VI.). Most of these intrusions occur in the sedimentary rocks, and have been cleaved and altered along with them. On the shore of Loch Gruinart, about three hundred yards south of Tayvullin, there is a lamprophyre dyke eight feet wide, which, though granulitised and distinctly cleaved, is apparently less deformed than many of the other intrusions. A little further south of the last dyke there are three small dykes, all cleaved with the sediments into which they have been intruded, and which are indurated along the point of contact.

On the north side of Kilchiaran Bay there is a fine example of a cleaved lamprophyre dyke intrusive in the Torridonian sediments.

Plate VII.



Cleaved Lamprophyre Dyke in Grits (Kilchiaran Series), North side of Kilchiaran Bay, 4 miles West of Port Charlotte, Islay.

CHAPTER XI.

DOLERITES.

These igneous rocks—regarded as presumably of Tertiary age—consist of dolerite intrusions, chiefly in the form of dykes, which traverse all the other rocks of the island in a north-west and south-east direction. They include two types of slightly different age, the earlier being represented by a single dyke of quartz-dolerite which crosses the Rhinns in a north-west direction from near Port Charlotte to Coul, and by the Ardnahoe dyke in the north-east part of the island. To the latter set belong the olivine-dolerites which occur in great profusion throughout the island and in some cases are seen to cut the above-mentioned earlier dykes.

Quartz-dolerite.—The best section showing the nature of this dyke and its relations to the other rocks is exposed on the shore at Loch Indaal Lighthouse, a little north of the village of Port Charlotte, where the dyke is seen cutting the sedimentary rocks and also a dyke of lamprophyre, and is in its turn traversed by an olivine-dolerite dyke. The quartz-dolerite dyke disappears under the raised beach for some little distance, but is seen again at Lorgbaw, east of Cnoc Thornasaig.

The dyke is next seen west of Cnoc na-h-Uamha, whence it can be followed for more than a mile and its contact with the sediments observed. To the east of Kilchoman Church it is once more lost under drift, but reappears on the other side of the valley at Cnoc Mor, east of Coul, and is last seen on the shore half a mile to the north-west, where it is cut by an olivine-dolerite dyke about seven feet wide. Specimens from the different localities have been examined under the microscope and in each case quartz has been observed, usually occurring as a constituent of micro-pegmatite. Biotite is sometimes present.

Olivine-dolerite.—Olivine-dolerite dykes occur in great numbers. The best sections are naturally found on the coast, those in the interior of the island being largely concealed by peat and drift. The general trend of these dykes is north-west and south-east. Sometimes they appear in groups so numerous as to be impossible to represent on the one-inch map; this grouping is particularly noticeable along the north-west coast of the Rhinns between Sanaigmore Farm and Ardnave Point. They are very abundant at Gortantaoid Point and eastwards along the northern coast-line, and occur thickly at Rudha Mhail, the extreme north point of Islay.

In the southern part of the island these intrusions are also frequent, but do not occur so much in groups as in the northern area.

The texture of these dolerites varies from coarse to fine, and in general they are coarse-grained in the centre and finer in their marginal portions. The coarser-grained varieties disintegrate freely with spheroidal weathering, and are dark-blue or greenish-black in colour, while the finer-grained are bluish-grey.

A specimen (5616) from a dyke intruded in the quartzite of Cnoc Breac, about three miles north of Bridgend, which may be taken as typical of the olivine-dolerites of the island, is composed of olivine, ophitic augite, lath-shaped plagioclase, and iron-ores. These olivine-dolerites appear to pierce the rocks in more or less vertical dykes which often send off branches, and include caught-up portions of the rock through which they have been injected.

We will now describe some variations from the ordinary type of olivine-dolerite. At Cnoc Rhaonastil, a little to the north-east of Kildalton House, a dyke stands up above the surrounding country, forming a bright green feature covered with luxuriant herbage and rising from the sea-shore to a height of 300 feet. This dyke has a breadth of about 300 yards and can be traced in a north-west direction for nearly a mile, cutting through the slates and sills of epidiorite. The spheroidal weathering of the dolerite is well displayed in a quarry on the roadside half a mile north of Kildalton House. The rock has also been wrought in another quarry, a little below the one just referred to, and has been used for ornamental purposes. Either polished or in its natural state it is a very beautiful stone. The principal constituents are labradorite, augite, olivine, and iron-ores; biotite and brown hornblende occur as accessories. The hornblende when present is usually attached to the borders of an augite individual. The augite is both idiomorphic and allotriomorphic with respect to felspar.

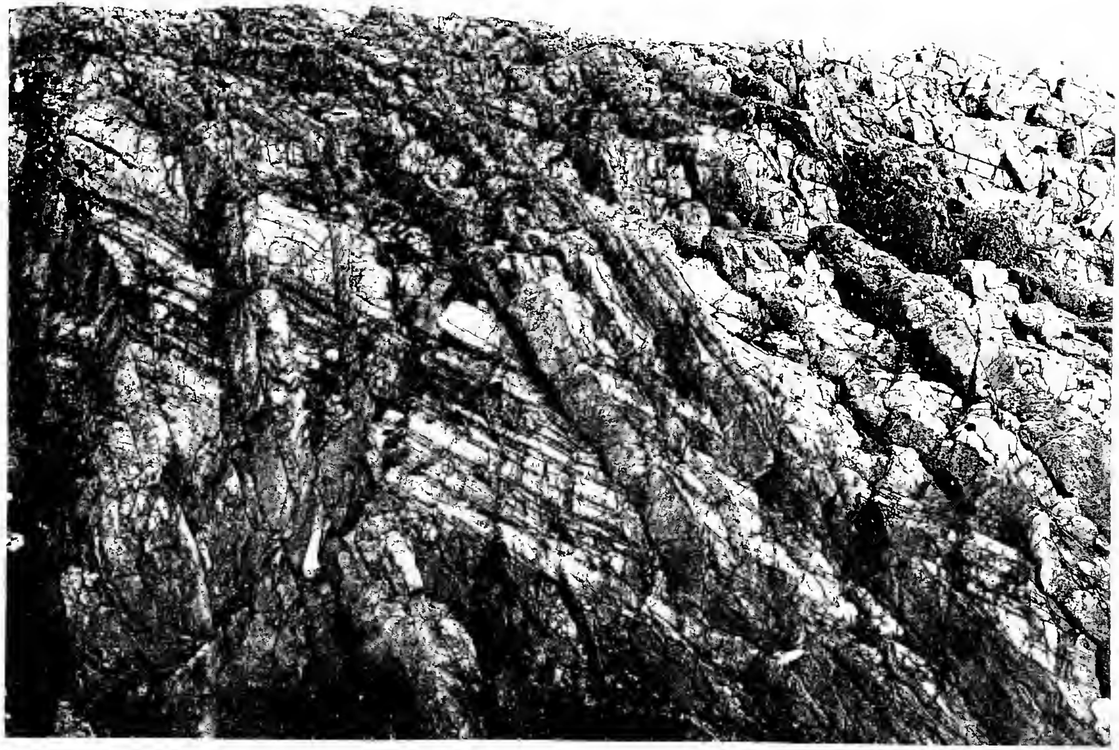
Corrary Hill Dyke.—At Corrary hill, about one and three-quarter miles south of Bowmore, an ophitic olivine-dolerite occurs which has produced a remarkable effect on the Torridonian grit which it traverses. In the quarry it is seen to have caught up a mass of highly-felspathic grit and has converted the portion immediately in contact with the dyke into an acid glassy mass. Nowhere else in this island has this type of contact metamorphism been noticed, but a similar result was observed by Dr. Horne in the Applecross district of Ross-shire.

Tigh-nan-Cnoc Dyke.—A very beautiful porphyritic dolerite, yielding an excellent stone for building purposes, has been quarried on the side of Tigh-nan-Cnoc, about two miles north-east of Bridgend. It is a black massive rock containing large tabular crystals of labradorite, sometimes measuring more than an inch across. The main mass of the rock is composed of olivine, ophitic augite, and lath-shaped plagioclase.

Some idea of the number of these olivine-dolerite intrusions in the north-western part of the island will be obtained, when it is stated that on Nave Island alone sixteen dykes have been mapped; and along the coast south from Ardnave Point no less than fifty of these intrusions have been observed within a distance of four miles. On the east side of Rudha na Creige Loisgte they form a perfect network of igneous material.

Along the western coast of the Rhinns, from Sanaigmore south-

PLATE VIII.



Dolerite Dykes traversing Kilchiaran Slates and Grits, Cliff West side of Kilchiaran Bay, 4 miles West of Port Charlotte, Islay.

wards to Kilchiaran Bay, the Torridonian rocks are pierced at frequent intervals by dykes of the ordinary olivine-dolerite type (Plate VIII.). At Port Ban, north-west of Coul, one of these dykes is seen to cut the earlier quartz-mica-dolerite dyke described on p. 63 at the point where the latter enters the sea.

In the Lewisian gneiss area southwards from Kilchiaran Bay to Rhinns Point the olivine-dolerite dykes are of less frequent occurrence. A short distance south of Lossit Bay four narrow intrusions of this rock unite to form a dyke which can be traced at intervals south-east across the island to the further shore near Port Caol. As we follow the eastern coast of the Rhinns northwards we find the olivine-dolerites increasing in number to the north of Port Gleann na Gaoith, fifteen of these dykes having been traced within a distance of a mile along the coast-line. Loch Indaal Lighthouse is built on the massive quartz-mica-dolerite dyke which has been referred to before as of the earlier type. It is here cut by an ordinary olivine-dolerite.

Dykes of the usual olivine-dolerite group occur in profusion in the north-eastern portion of the island, where they are intruded into all the metamorphic rocks of the Northern Series. They are especially numerous along the shores on either side of Rudh a' Mhail and on the north coast between Rudha Bholsa and the mouth of Loch Gruinart, where thirty-one of these dykes have been traced in the quartzite. Inland they traverse the quartzite, shales, and dolomite on either side of Sgarbh Breac, at the head of the Margadale river, and cross the hill of Guir-bheinn. At Ardnahoe Farm and forming the north-east shore of the loch of that name, is a well-marked dyke of coarse dolerite. This dyke has been traced for a distance of more than three miles to the Doodilmore river, its trend—east-south-east and west-north-west—varying somewhat from that common to most of the Tertiary dykes. There is strong presumptive evidence that this dyke is cut on either side of Guir-bheinn by two of the more northerly dolerite intrusions. On the shores of Loch Gruinart, at Bun-an-uillt, a group of eleven dykes of olivine-dolerite occur in close proximity, and further to the north, along the edge of the blown sand, there are several dykes of the ordinary type. A massive dyke with spheroidal weathering crosses Cnoc Breac, north of Loch Drolsay. A description of this rock has already been given (5616).

In the Torridonian grits to the north-west of Bridgend, and in the limestone area between Scarrabus and Balachlavin, there are numerous dykes of the ordinary olivine-dolerite type, and one, the Tigh nan Cnoc dyke, which has already been referred to as differing slightly from the normal type. Another conspicuous dyke of dolerite can be traced for a distance of about nine miles from Beinn Breac past the village of Ballygrant to the shore of the Sound of Islay. The general trend of this dyke is north-north-west and south-south-east, but in Gleann Logan, near the shore of the Sound of Islay, its direction deviates to the east for a distance of three-quarters of a mile. Throughout the districts of Balulve, Keils, Keppolsmore, and Kilmeny the olivine-dolerite dykes are again very numerous, cutting the different members of the limestone and phyllite series and preserving a general north-west and south-east trend. The Portaskaig conglomerate along the shore of the Sound of Islay is also traversed by numbers of these dolerite dykes, and they occur again in great abundance in the quartzite on the opposite coast of Jura.

Returning to the eastern shores of Loch Indaal we find small dolerite dykes intruded into the Torridonian rocks at many places. On Cnoc Loisgte, a hillock south of the second milestone from Bowmore, the grits are pierced by a group of six dykes somewhat erratic in their course, though preserving the general north-west and south-east direction.

Many of these dykes also occur in the phyllite and limestone area to the south and south-east, and within the main quartzite belt the Tertiary intrusions are of frequent occurrence.

All the dykes referred to above appear to be of the ordinary olivine-dolerite type, and have the usual north-west and south-east trend, with occasional slight deviations towards a more northerly direction. Similar dykes are numerous along the south-eastern shores of the island from Carraig Mhor round Ardmore Point to Port Ellen, and traverse the phyllites and epidiorite sills in the neighbourhood of Ardbeg, Lagavulin, and Laphroaig, and in the island of Texa.

They also occur in great profusion along the south-east and north-west shores of the Oa promontory. In the quartzite belt that fringes the western coast, the weathering-out of the softer igneous rock under the action of the Atlantic waves has given rise to numerous deep gullies and caverns in the cliff face.

S. B. W.

CHAPTER XII.

FAULTS.

Most of the principal faults which enter into the structure of the island have been already referred to in the foregoing chapters. As will be seen by a glance at the map, the faults are more numerous in the northern than in the southern area of the island. The important reversed fault, referred to as the "Skerrols thrust' that extends from the shores of Loch Gruinart to Laggan Bay, and by which the quartzite is thrust over the Torridonian rocks, has already been described in Chapter VII. On the east coast of Islay the quartzite has been thrust over the limestone and phyllite series by another thrust-plane whose outcrop extends inland in a southerly direction from a point on the shore of the Sound a little south of Am Meall, but seems to die out to the south on the northern slopes of Beinn Bhan. The quartzite along the margin is somewhat sheared and drawn out, but has not suffered the same amount of deformation as along the line of the Skerrols thrust.

A system of more or less parallel faults occurs in the northern area, north-west of the Finlaggan valley, which itself seems to have been determined by a fault. North-east of Finlaggan Loch the dislocation varies in effect; the greatest amount of "throw" appears to be where the "Fucoid beds" on the north-west of the fault have been brought down against the Islay limestone, but here, as in many other localities, the rocks are largely hidden by superficial deposits, and it is only at intervals that small outcrops of rock give an indication of the existence of a line of fault.

Three more or less parallel faults extend from near Loch Cam in a northerly direction, repeating the higher portion of the quartzite with the upper conglomerate, and the overlying Fucoid beds and piped quartzite. Two of these faults appear to die out to the north but the central fault can be traced over the slopes of Beinn Bhreac and Sgarbh Dubh to the north coast.

These faults all have an upthrow on the west repeating the different groups, so that they appear on the map in long narrow belts. Another fault parallel to the last named has been traced from the south end of Guir Bheinn in a line almost due north to the sea at a point a few hundred yards east of Rudha Bholsa, where the quartzite in the vicinity of the fault is in an intensely shattered and brecciated condition.

An important fault runs inland in a southerly direction from Na Feamindean, on the shore of the Sound of Islay. By this dislocation the highest beds of the group on the east side of the fault are brought down against the lowest which appear on the west. This fault appears to be lessening towards the south. On the west shoulder of the Oa promontory a line of fault with a downthrow to the west brings down the quartzite against the phyllites. The line of junction where seen in the coast section is marked by the intensely shattered condition of the rocks of both formations and the occurrence of innumerable quartz reefs.

In the neighbourhood of Coillabus, also in the Oa area, two small parallel faults occur rather more than half a mile apart, which shift the strata slightly and throw back the boundary between the quartzite and the phyllite series, but are otherwise of little importance in the structure of this district.

In addition to those particularised above there are innumerable smaller normal and reversed faults too minute to indicate on the map. These can be best seen on the shore sections, particularly in the quartzite along the northern coast of the island. Individually these minor faults are of little structural value, but taken together must produce considerable effect by the constant repetition of the beds; and in combination with the system of rapid folding which prevails over a large portion of the island, create a false impression as to the great thickness of the strata involved in the area.

S. B. W.

CHAPTER XIII.

RECENT AND POST-TERTIARY.

GLACIAL DEPOSITS.

Direction of Ice-flow during the period of maximum glaciation.—A glance at the accompanying sketch map, upon which the glacial striæ observed have been recorded, will demonstrate that at the period of maximum glaciation Islay was traversed by an ice-sheet which moved across the island from south-east to north-west. Local variations, due to the form of the ground, are observable, notably the effect of the central hollow in deflecting the flow towards the west. B. N. P.

The general direction of the ice-movement as shown by the striæ is from east-south-east to west-north-west. (See Fig. 6.) In the northern part of the island the movement was north-west, with a local variation in the neighbourhood of Portaskaig to west 15° south.

The quartzite area between the Mull of Oa and the Sound of Islay yields innumerable examples of striated rock surfaces, especially on Glas Bheinn (1544 feet) to the north of Loch Allallaidh, where the south-east and north-west striæ are engraved deeply on the polished surface of the quartzite. The quartzite hills in the north of the island show similar striation almost anywhere on the higher ground.

A fine example of glaciation of the softer rocks is seen on the roadside at the base of Mulreesh Hill, immediately before turning off to Finlaggan Farm, where the soft phyllites have been deeply scored and polished by the ice, two sets of striæ being visible. In the north of the Rhinns of Islay round the west shore of Ardnave Point the Torridonian slates and grits show finely-striated surfaces. The striæ seen on the exceptionally hard rocks of the Lewisian gneiss at Portnahaven are also remarkable for clearness and depth, particularly along the shore in front of the hotel.

Boulder Clay.—This deposit generally presents the character of a tough argillaceous or arenaceous clay, varying from bright brick-red to light-brown or grey in colour, and plentifully charged with well-rounded and striated boulders. These consist of quartzite, quartz-schist, limestone, epidiorite, dolerite, slate, phyllite, red sandstone, purple or red porphyrite, and andesite, with a few of red granite. On the Rhinns of Islay the drift also contains boulders of Lewisian gneiss and Torridonian rocks.

Of these, the blocks of andesite and red sandstone are foreign to the island, but some of the red granite constituents may have been derived from the Portaskaig conglomerate, which includes many fragments of a red granite not unlike it in appearance. The

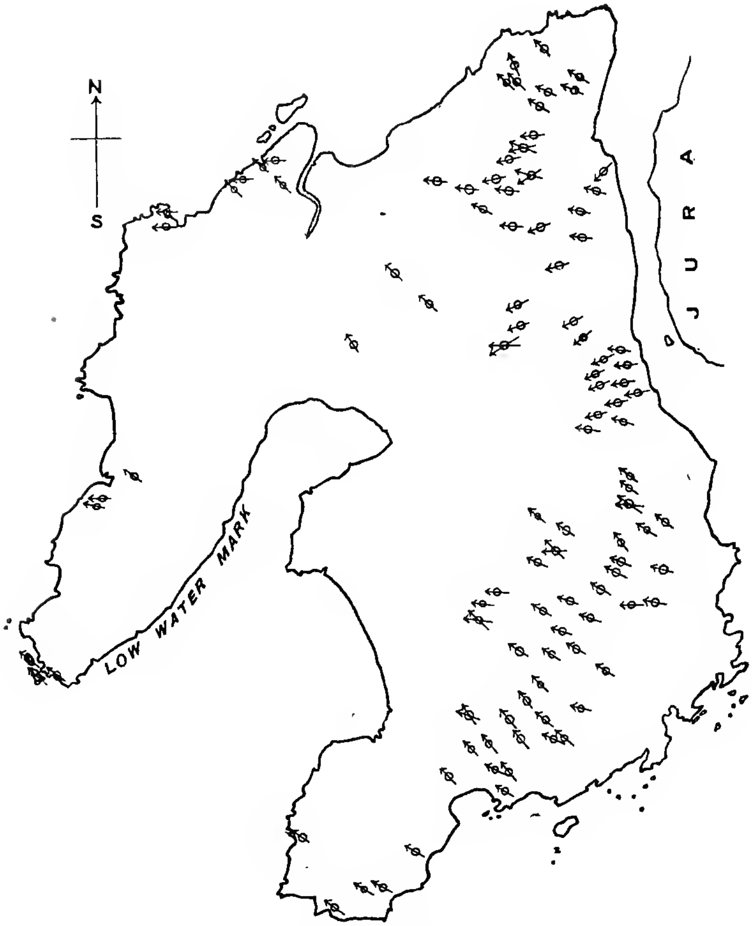


Fig. 6.—Sketch Map, showing direction of Ice-flow, Islay.

blocks of porphyrite found in the northern portion of the island may have been brought from Jura; those of red sandstone and andesite in all probability came from the mainland.

The prevailing colour of the boulder clay throughout the island is some shade of red, though the upper portion of the deposit is often bleached and faded. The intense red colour of the till that caps the quartzite cliffs at M'Arthur's Head at the southern entrance of the Sound of Islay, and flanks the sides of Glen Ghaireasdail and Glen Logan, is very striking. The occurrence in the Mull of Oa of a red sandstone breccia, to which a Triassic age has been assigned, suggests that the colour of the boulder clay may be due to a former covering of red sandstone of that period which has been removed by denudation. A similar origin may be suggested for the red staining of the joint-planes in the quartzite, observed in many parts of the island, but especially in the Mull of Oa.

The boulder clay is more largely developed on the north-western than upon the south-eastern slopes of the higher ranges, a fact due no doubt to the shelter afforded by the high ground. At the same time there are large areas of this deposit in the glens on the south-eastern side of the hills, where the streams are often cutting through deep banks of till.

On the Oa promontory the boulder clay is not developed to such an extent as in other parts of the island. This is probably owing to the absence of any high ridge behind which the till could accumulate. To the east of Loch Gruinart the north-western slopes of the hills are swathed in deep boulder clay, which stretches in gentle slopes from about the six-hundred-feet contour-line to the shore or to the margin of the raised beach. This mode of occurrence of the boulder clay is found also in the Rhinns of Islay, but there the drift does not attain so great a depth as on the north-west slopes of the main quartzite range.

In the area between the river Laggan and its tributaries the Duich and Torra, as far east as Kilennan, the boulder clay is very deep, and excellent sections of a tough red clay can be observed along the course of the Laggan river. Although the stream has cut down some forty feet into the till, the bottom has not yet been reached. The upper portion of the deposit occasionally contains interstratified beds of sand and gravel a few feet in thickness, probably laid down by interglacial streams. S. B. W.

Moraines.—On the disappearance of the early ice-sheet from the low grounds the quartzite ranges seem to have nursed their individual glaciers; for moraines are found in most of the glens, and are sometimes disposed concentrically where the valleys debouch upon the plain. Such a concentric group of moraines is conspicuously displayed immediately to the east of the road between Port Ellen and Bridgend, where, between the former locality and Leorin farmhouse, several large moraines rest upon the hill-slope.

In Gleann a' Chardaidh, and at the head of the Bun-an-uillt stream, on the east side of Loch Gruinart, small rounded hillocks and mounds of morainic material are very numerous.

Glacial Sands and Gravels.—In addition to boulder clay and glacial material arranged in moraines, there are considerable deposits of gravel and sand which are probably also of glacial origin. Some of these are arranged in narrow sinuous ridges (kames or eskers), and are probably englacial material left by the disappearing ice-sheet. These are sometimes associated with more wide-spread deposits of similar material. B. N. P.

Both types occur in the neighbourhood of Torra Farm, where the Bridgend and Port Ellen road passes for a distance of more than a mile over deep deposits of stratified sand and gravel. An exceptionally good section is exposed on the west side of the road, where a small streamlet has deeply eroded these deposits. About a quarter of a mile south of Torra an esker-like ridge runs from the road in a south-western direction for a distance of 600 yards. Another similar ridge appears on the eastern bank of the Torra river, and trends in the same direction for about the same distance. The elevation of these ridges is about 200 feet above sea-level. Further down the Torra river the boulder clay is covered with several feet of stratified sand and gravel.

Similar masses and ridges of gravel are seen north of Sunderland Farm, near Loch Gorm. Kamiform ridges also cross the peaty flat near the head of An Rumach on the high ground to the east of Loch Gruinart. S. B. W.

A wide-spread deposit of sand and gravel lies on either side of the road that leads north from Port Ellen to the Laggan river, and also extends to a height of about 600 feet at the foot of the quartzite hills, where it has been terraced and deeply trenched by the streams which flow westwards off that range. The deposit probably represents the confluent deltas of these streams formed at a time when the flow of water from the hill-slopes was much larger than at present. The drainage was probably retarded by lobes of ice from the mainland occupying the low ground of Islay during the recession of the ice-sheet.

Marine Alluvium.—In addition to the present beaches and the sand and mud flats left dry at low water, remains of raised beaches occur at several levels, marking successive stages in the elevation of the island. Three of these beaches are more conspicuous than the rest, and doubtless indicate longer pauses between the periods of elevation. The highest of these has its upper limit generally about the 100-feet line and may be called the 100-feet beach. Another lower beach extends upwards to about the 50-feet line, and a third has its upper limit somewhere about 20 feet above Ordnance datum.

100-feet Beach.—The "hundred-feet" beach, which dates back to glacial times, forms a wide bench on the east side of Loch Gruinart, stretching continuously from near Bun-an-uillt to the shore halfway between Gortantaoid Point and the Rudha Bholsa, and is continued at intervals round the north and east coast as far as Bonahaven Bay. On the exposed north-west coast its upper limit is often marked by a "storm beach" of well-rounded pebbles of quartzite, still bare of vegetation, which rises considerably above the 100-feet contour-line. This beach forms a very striking feature along the shores of Jura, on the opposite side of the Sound of Islay. B. N. P.

The 100-feet beach is found at intervals on both sides of the Rhinns of Islay between Ardnave Point and Portnahaven. It forms a wide terrace round Loch Gorm and extends at intervals across the low flat which separates Loch Gruinart from Loch Indaal, indicating that, during the formation of the 100-feet beach, the Rhinns was separated by water from the rest of Islay, and the northern portion of the Rhinns was also broken up into an archipelago.

The 100-feet beach is well represented on the east side of Loch Indaal between Bridgend and Bowmore, the Monument Hill, already referred to, appearing as an island above its level. It forms a peat-covered flat above two miles in width near the mouth of the Laggan river, and fringes Laggan Bay to within a short distance of Port Ellen. In this region it merges upwards into the wide delta of fluvio-glacial origin already referred to as stretching upwards to the foot of the quartzite hills. The beach also sends a tongue across the watershed into Kilnaughton Bay, showing that the Mull of Oa must have been a separate island during the period of its deposition. S. B. W.

Peat-covered remains of this beach are found inland between the epidiorite ridges along the south coast between Port Ellen and Ardmore Point. It also occurs at intervals along the east coast northwards from the latter point to near M'Arthur's Head.

B. N. P.

Fifty-feet Beach.—The fifty-feet beach is represented by a lower terrace in most of the localities where the 100-feet beach has been preserved. It occurs on both sides of Loch Gruinart and extends across to Loch Indaal, where the mode of its occurrence also shows that during its deposition the Rhinns formed a separate island.

S. B. W.

This beach extends at intervals along the shores of the Rhinns and pushes inland for short distances at the heads of the bays which indent the shore-line. It also forms a more or less continuous fringe round the head of Loch Indaal and Laggan Bay. On the south coast it occurs at the head of sheltered bays on both sides of Port Ellen and as far eastward as Ardmore Point. It is found on the Jura shore of the Sound of Islay, and forms a considerable proportion of the interior of Oronsay, the southern extension of Colonsay, which falls within the area at present under consideration. B. N. P.

The twenty-five-feet beach is usually marked by a conspicuous cliff at its upper limit, indicating a long pause, during which the elevatory forces were inactive over the area. It forms a wide area of cultivated ground at the head of Loch Gruinart known as the Gruinart flats, which extends almost across to Loch Indaal. It also occurs at intervals round the Rhinns, but is often represented only by a "rock-notch" on the exposed shores where the configuration of the ground favours its retention. This beach reaches its greatest development round the head of Loch Indaal and on the shores of Laggan Bay, where it is much masked by blown sand. It also occurs on the south shore in most of the bays on the sides of Port Ellen. It is represented by a rock-notch on the exposed shores of both Islay and Jura and outlying islands, and also round the shores of Oronsay.

Fossils are rare in the raised beaches of Islay, but the coral *Cariophyllia* was found by Dr. Peach attached to the cliff at a height of 10 feet above high-water mark, at a point on the shore of the Sound of Islay about a quarter of a mile north of Portaskaig. This coral does not exist above low-water mark, and its mode of occurrence indicates that it lived during the deposition of one of the higher beaches. S. B. W.

The present beaches are being formed in precisely similar positions to those of the older beaches. On the exposed coast a rock-notch is in course of erosion, while sand and mud are being deposited at the head of the quieter bays. B. N. P.

Blown Sand.—Large accumulations of blown sand are found in several districts of the island. One of the chief areas lies along the shores of Laggan Bay, which facing to the west receives the full force of the Atlantic gales. The sand has been driven inland for a distance of three-quarters of a mile, sometimes forming large dunes, which are covered with a growth of marram grass. The close proximity of peat and alluvium, in addition to the marram grass, have prevented further encroachment of the sand. The strand of Laggan Bay, from which the sand is derived, extends for nearly five miles from the mouth of the Laggan river to Kintran; it is remarkable for its extreme whiteness. Small cowrie shells (*Trivia* (*Cypræa*) *Europea*) occur on this strand, the only locality in the island where they have been noticed.

At Kilnaughton Bay, to the west of Port Ellen, the sand has been blown inland over a small area and banked for a considerable height against the hillside.

At Lossit Bay, about three miles north of the village of Portnahaven in the Rhinns of Islay, the blown sand rises to a height considerably over the two-hundred-feet contour-line. The Lewisian rocks along the coast-line have been beautifully polished by the action of the driving sand, and the contrast between the dark basic and lighter acid bands on these highly-polished surfaces is most striking. At Machir Bay, about midway along the west coast of the Rhinns, the sand has been piled up by the Atlantic storms to a height of a hundred feet above sea-level and carried inland almost as far as the old church of Kilchoman. Here also the slates and grits on the shore have been polished by the driving sand.

Smaller areas covered with blown sand occur at Saligo Bay, the Traigh Bhàn, and Sanaigmore Bay, along the west coast of the Rhinns.

The sand dunes on both sides of the entrance to Loch Gruinart form a very striking feature. On the west side they extend from Ardnave Point to the hamlet of Tayvullin, a distance of two miles, and vary in breadth up to as much as a mile, the sand reaching the one-hundred-feet contour-line. On the east side of the loch the sand dunes do not rise above fifty feet, but extend for a distance of some three miles along the coast.

Peat.—Large areas of peat exist in many parts of the island. The peat varies much in depth, and where it occurs on the hill-slopes is often of no very great thickness. The principal peat-mosses are found north of the town of Port Ellen, between Kildalton and Ardmore, and at several localities in the Oa promontory. Large tracts of peat also occur on the hill slopes east of Glenegedale on the western coast, between the Laggan and Duich rivers, and north of Laggan Point. Throughout the area of the Rhinns peat is largely developed, more especially in the Port Charlotte district, as also in the neighbourhood of Gruinart and round Loch Gorm. In the north-eastern portion of the island considerable areas of peat occur near Bonahaven and north of Finlaggan. In all these localities, which are within easy access from the villages and farmsteads, the peat is cut yearly. Large quantities are also used in the many distilleries in the island to produce the smoky flavour characteristic of the Islay whiskies.

Alluvium.—Freshwater alluvium has been laid down along the courses of the principal streams—the Laggan, the Sorn, and the Kintour rivers. Many of the smaller streamlets have also their alluvial terraces, but they are as a rule too small to be indicated on the map,

Between Cattadale Farm and Mulindry Bridge the Laggan river runs through a narrow alluvial tract, where its banks are low and liable to be flooded. After cutting through rock and boulder clay for a short distance, it again shows alluvial margins on each bank, sometimes extending to four hundred yards in breadth. Below the mouth of the Kilennan river the alluvium is very narrow, and occurs only on one side of the stream, but broadens out again immediately above Laggan Bridge. At Bridgehouse the stream has laid down a wide expanse of alluvium which continues to the margin of the blown sand.

Along the upper part of the Sorn river the alluvial belt is narrow and ceases entirely at Emeraconart. Below the rock gorge at Stone Cottage the river enters a wide alluvial plain. On its northern margin, near Newton, there appears to be a higher terrace whose limits are ill-defined. The Kintour river also passes through alluvial flats from the farmhouse of that name to the sea at Aros Bay. S. B. W.

CHAPTER XIV.

ECONOMIC RESOURCES.

GALENA.

In the district around the village of Ballygrant, between Bridgend and Portaskaig, veins of galena are frequent in the Islay limestone. At Mulreesh a large mine was formerly worked and appears to have been at one time a profitable undertaking; but a fall in the price of lead, coupled with increased cost of production, led to considerable loss, and the mine has been closed.

An Assay of silver lead from Mulreesh, Islay, by Mr. M. W. Bawdon, kindly supplied by Mr. Archer, the engineer of the mine, showed 6½ ozs. of silver to the ton.

From the old surface workings it appears that the lead occurred in the form of pockets, and pinched out too soon to be profitably worked at current prices.

Robolls mine, in connection with the Mulreesh mine, was worked more recently and a fair sample of lead obtained, but not in sufficient quantities to be profitable.

MANGANESE.

This mineral occurs in the form of a network of veins or strings through the quartzite in the south of the Oa promontory, at the base of a fine cliff called Dun Athad. Many years ago it was worked and is said to have been worth £4 per ton, but from the great difficulty of access the work was given up.

BUILDING STONE.

The building stones of the island are of no particular value. The rocks most in use for this purpose are quartzite, epidiorite, chlorite-schist, and dolerite, the last-named being generally used for the better class of buildings. Some of the close-grained chlorite-schists have been worked up into chimney-pieces, &c. The beautiful sculptured crosses of the island are generally made from this rock. Some of the dolerites are also capable of being wrought for ornamental purposes, in particular the olivine-dolerite of the Cnoc Rhaonastil dyke, which is very fresh, and when polished makes a handsome stone. The porphyritic epidiorites could also be worked up into ornamental structures. Some of the Lewisian gneiss would polish effectively, particularly that on Orsay island off the south of the Rhinns of Islay.

LIMESTONE.

The limestone of Islay is valuable for agricultural purposes, but is not much used for building stone.

SLATE.

Slates have been obtained from at least three localities in different parts of the island, in only one of which, however, is the rock wrought at the present time. This quarry is at Kilchiaran, in the Torridonian slaty group of the west coast of the Rhinns of Islay, and the slates raised are rough, heavy, and of small size. The numerous dykes of mica-trap which traverse these slates cause a great deal of waste in quarrying. The other two localities are at Emeraconart between Bridgend and Portaskaig, and near Port Ellen Lighthouse, in the Esknish slates, the equivalent of the Easdale slates of the mainland. From both these quarries a coarse, heavy slate was raised, but they have now been closed.

ROAD METAL.

The epidiorites, chlorite-schists, dolerites, and limestone, and the gneiss of the Rhinns all afford excellent and durable road metal. There are, however, large areas, where the roads pass through a quartzite or slate district, in which the surface is indifferent, owing to the want of some of the rocks referred to above. Quartzite will not bind well by itself, and requires some other rock to go with it. Dolerite dykes occur in all parts of the island, and this rock could be much more used than at present to mix with the less binding varieties, a practice which would insure a good road. The quartzite shingle of the raised beaches is, however, near at hand, and more easily placed on the road, the consequence being a bad, if not a dangerous road, where with a little more energy and knowledge a good one might be provided.

PEAT.

The peat deposits over the island are of vast extent and practically inexhaustible. Although peat is in general use for fuel all over the island, and also used in large quantities by the numerous distilleries to give the spirit the correct amount of " reeky " flavour which is a feature of the excellent whisky of Islay, the amount that has been " cut " is trifling as compared with what remains.

S. B. W.

APPENDIX.

List of Publications referring to the Geology and Mineralogy of Islay.

1774. Pennant, T. A Tour in Scotland and Voyage to the Hebrides.

1790. Mills, A. Some Account of the Strata and Volcanic Appearances in the North of Ireland and Western Islands of Scotland. *Phil. Trans. Roy. Soc.*, Vol. LXXX., p. 73.

1800. Jameson, R. Mineralogy of the Scottish Isles. In 2 vols. Vol. I., pp. 148-166.

1814. Macculloch, J. Miscellaneous Remarks accompanying a Catalogue of Specimens transmitted to the Geological Society. *Geol. Trans.*, Vol. II., p. 412.

1819. Macculloch, J. The Western Islands of Scotland, Vol. II., p. 223; Vol. III. plate 22. General Map of the Western Isles and Map of Isla, Jura, Colonsay, Oransa.

1824. Vetch, Capt. Account of some Terraces, or Ancient Beaches, in the Isle of Jura. *Geol. Trans.* Second Series, Vol. I., 1823-24, p. 416.

1840. Macculloch, J. A Geological Map of Scotland.

1844. Nicol, J. Guide to the Geology of Scotland, with Geological Map. 8vo. Edin. p. 225.

1858. Nicol, J. A Geological Map of Scotland.

1861. Murchison, Sir R. I. and [Sir] A. Geikie. On the Altered Rocks of the Western Islands of Scotland, and the North-Western and Central Highlands. *Quart. Jour. Geol. Soc.*, Vol. XVII., p. 206.

1862. Murchison, Sir R. I. and [Sir] A. Geikie. First Sketch of a New Geological Map of Scotland, with explanatory notes.

1872. Thompson, J. On the Stratified Rocks of Islay. *Brit. Ass. Rep. for the year 1871*, Vol. XLI., p. 110.

1877. Thompson, J. On the Geology of the Island of Islay. *Trans. Geol. Soc., Glasgow*, Vol. V. (1874-76), p. 200.

1888. Anderson, J. Glaciation and Raised Beaches in Jura and Islay. *Trans. Geol. Soc., Glasgow*, Vol. VIII., p. 316.

1892. Geikie, Sir A. Geological Map of Scotland, reduced chiefly from the Ordnance and Geological Surveys. Edin.

1894. Geikie, Sir A. Report of the Director-General of the Geological Survey for 1893, p. 265.

1895. Geikie, Sir A. Report for 1896, p. 26.

1898. Wilkinson, S. B. Geology of the Rhinns of Islay. Summary of Progress of the Geological Survey for 1897, pp. 62-64.

1899. Geikie, Sir A. Old Red Sandstone Lavas of Glas Eilean, Sound of Islay. *Ibid.* for 1898, p. 75.

1900. Peach, B. N., and S. B. Wilkinson. Geological Structure of the Island of Islay. *Ibid.* for 1899, p. 66.

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